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DATE 12 APRIL 1968

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ANALYSIS OF CREW ESCAPE INITIATION RESPONSE CHARACTERISTICS FROM TITAN IIIM/GEMINI B STAGE "0" ABORT SIMULATION

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SUBMITTED UNDER USAF CONTRACT NO. F04695-67-C-0023

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1. INTRODUCTION

Extensive study during the USAF Manned Orbiting Laboratory (MOL) Program has identified situations and conditions during the ascent phase that will force a mission abort and has led to selection of crew escape procedures based on launch vehicle and spacecraft flight performance. The success of these procedures and the assurance of crew safety that they represent are highly dependent upon a precise sequence of events that is manually initiated by the crew.

The subject simulation was designed to expose a representative sample of the MOL flight crew to the Stage "0" ascent abort situations. The primary objective of the program was to evaluate the crew's capability to respond positively and accurately to initiate abort/escape action under simulated high stress conditions. The secondary objective was to evaluate the overall adequacy of the crew displays relative to malfunction monitoring during Stage "0" operation. In addition, the simulator was to be used on a time-available basis for general flight crew indoctrination.

The moving-base-simulator facilities of LTV Aerospace Corporation, Dallas, Texas, were used for the program. Martin Marietta Corporation, Denver Division, and McDonnell Astronautics Company, St. Louis, Missouri, defined the test program and provided on-site support for the conduct of the simulation. The work reported herein was performed under CCN 37 to Contract F04695-67-C-0023.

After the conclusion of the LTV program it was found desirable to have data that were not available from the basic simulation. A supplementary test to obtain these data was performed at McDonnell Astronautics Company using MOL flight crew personnel.

2. SUMMARY

The program objectives have been met by the simulation results. The capability of the crew to manually perform the abort/escape functions was established and the adequacy of the controls and displays was demonstrated.

In the analysis of the crew response time data, the influences of malfunction type, time of abort, and cues for escape action timing have been studied and the response characteristics classified. The major output of the analysis is the definition of engineering models of crew performance with which escape initiation procedures can be evaluated and optimized. The procedures included in the simulation program were evaluated on the basis of these engineering models.

Evaluation of the Mode A procedures was made academic by the fact that crew response in all simulated aborts was better than required for safe escape. The current procedures for ejection timing based on kinesthetic cues and available displays proves to be adequate with sufficient margin to allow for any foreseeable disparity between the simulation and actual flight. The addition of the EJECT light does appreciably reduce the variations in response times, but with the present safe ejection window the necessity for the narrower response spread does not exist.

The evaluation of Mode B procedures shows that a significant improvement in safe escape probability and a simplification of the crew task is achieved when a rate threshold value higher than the current 5.5 degrees/second is used to activate the RATE light. An optimization procedure is developed that combines the probability of malfunction occurrence with the engineering models of response time to define a rate threshold that minimizes overall crew risk.

Use of the FDI needles for detecting the rate threshold suggested that further improvement in safe escape probabilities is achieved by the added

2. (Continued)

anticipation that is lacking with the discrete light cue. The engineering model of crew performance using the FDI cue is qualified by the limited amount of data measured. The recommendation is made to further evaluate use of the FDI cue, and to implement in the launch vehicle MDS the rate threshold found to be optimum following the pending study of launch vehicle motion tapes.

The display and controls evaluation was primarily based upon constructive criticisms from the crew and the success achieved in the test using the current display and controls configuration. The only displays that did not prove adequate were the warning lights on the Stage I pressure indicator and the TVC lights on the Stage "O" indicator. The lights present the same appearance with either one or both of the redundant bulbs lighted. Subsequent investigation in conjunction with the light module vendor has shown that placing a separator between the bulbs rectifies the situation.

3. BACKGROUND

3.1 Abort Mode Definitions - The Stage "0" portion of ascent extends from Solid Rocket Motor (SRM) ignition until SRM burnout at approximately 120 seconds into flight. Almost the entire atmospheric flight is covered by Stage "0" and the escape problems range from low altitude recovery over land in the early portion to spacecraft separation and clearance in the high dynamic pressure region. Accordingly, Stage "0" employs two abort modes wherein the implementation of crew escape is affected by specific conditions.

Abort Mode A, used on the pad and during early flight, consists of severing the spacecraft from the flight vehicle at the equipment adapter/retro adapter separation plane, salvo firing the retro-rockets, and flying a controlled separation trajectory until retro burnout at which time the crew ejects. This procedure is limited by a maximum ejection altitude of 15,000 feet which is exceeded for escapes initiated after 32 seconds of flight. Figure 3-1 shows a typical Mode A trajectory and sequence of events for an abort on the pad. The primary hazards in Mode A escapes occur after the crew ejects, and are due to heating from the expected fireball at the launch vehicle which will degrade personnel chute strength if it is deployed within 900 feet of the fireball center, and to altitude above the local terrain which must be at least 75 feet at the time of chute stabilization. The heating problem exists throughout the Mode A regime, whereas chute stabilization altitude ceases to be of consequence for escapes initiated more than 10 seconds after lift-off. In order to shape the escape trajectory and control the spacecraft attitude at the time of ejection for aborts on or near the pad, a Pad Abort Control System (PACS) provides a programmed pitch rate control and yaw rate damping. The Reentry Control System (RCS) augments the pitch program and provides roll rate damping. The ground

MODE A PAD ABORT TRAJECTORY

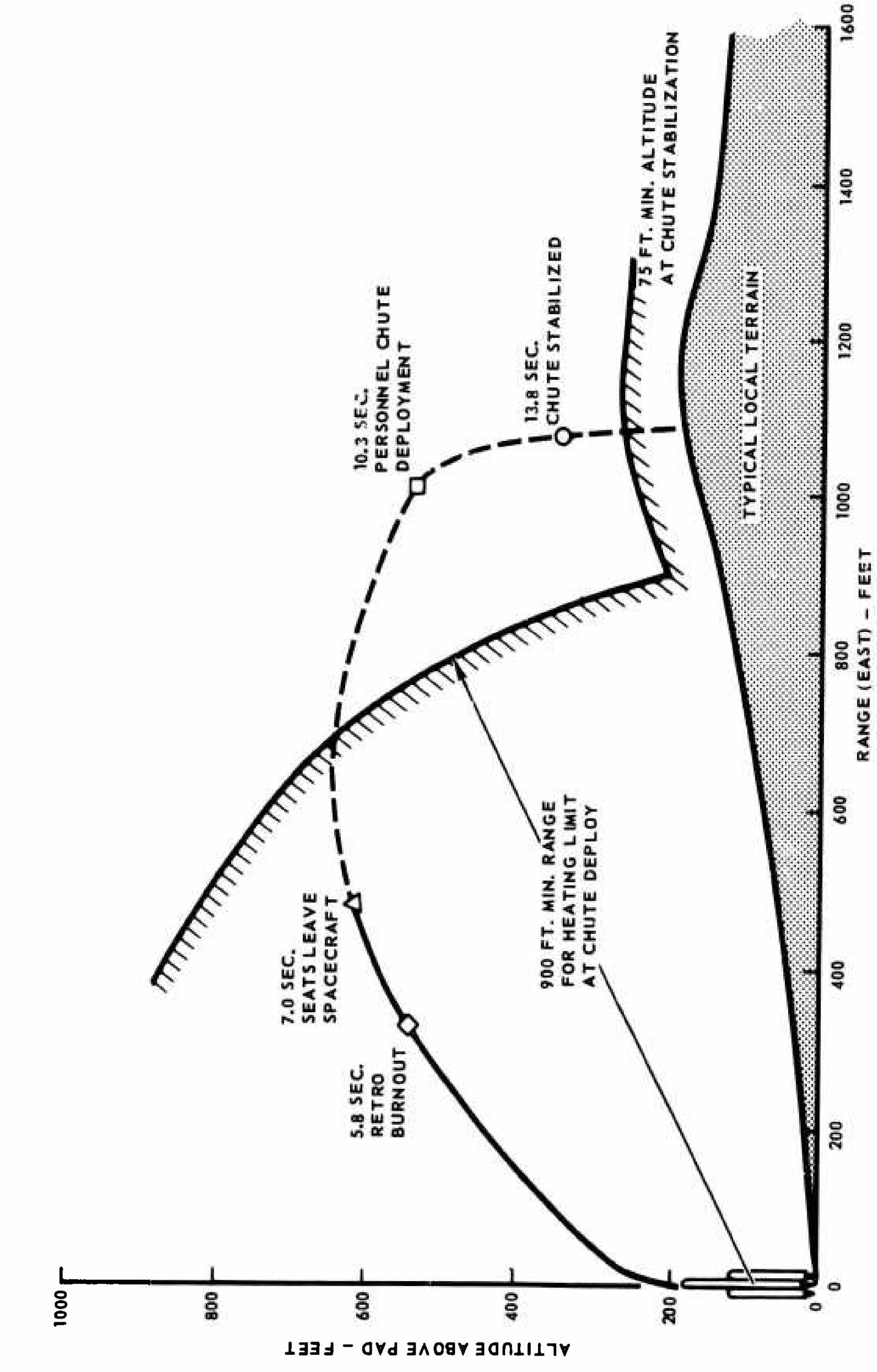


FIGURE 3-1

3.1 (Continued)

winds at launch time are used to advantage by selecting one of two PACS control programs to direct the escape trajectory either east or west in order to fly as nearly downwind as possible. Mode A aborts after lift-off use the same PACS program selected for pad abort.

Abort Mode B differs from Mode A in several respects, one being that the spacecraft parachute recovery system is the basic recovery method. After retro burnout the retrograde adapter section is jettisoned, the drogue parachute is deployed (at altitudes less than 40,000 feet), and the main parachute is deployed at 10,600 feet. If spacecraft impact on land is imminent the crew must eject. The minimum altitude for deployment of the main spacecraft recovery system is 4,900 feet. A Mode B abort can be initiated as early as 21 seconds after lift-off. A nominal Mode A/B switchover time has been selected at 27 seconds after lift-off to coincide with a change in launch vehicle abort sequence. The specific hazards associated with Mode B aborts are directly related to the flight environment. To be successful, sufficient relative acceleration between the spacecraft and launch vehicle must be provided so that subsequent recontact is precluded and adequate clearance from destructive overpressure in the event of launch vehicle propellant explosion is obtained. At high dynamic pressures spacecraft drag is large with respect to retro-rocket thrust and adequate acceleration cannot be achieved until the spacecraft axial force decreases. This situation is further aggravated by a residual thrust following SRM thrust termination. Extensive analyses of Mode B separations led to a procedure where the launch vehicle Malfunction Detection System (MDS) applies a hardover pitch-up command simultaneously with the thrust termination command. With this procedure, safe separation can be achieved at a shorter time after shutdown, a consistent

3.1 (Continued)

type of motion following abort is produced regardless of the malfunction, and correlation exists between the resultant pitch rates and the earliest time at which successful separation can be achieved. The pitch rate build-up, however, is dependent upon the extraneous forces induced as a result of each particular malfunction. An upper limit on the period during which escape separation can be performed is assumed to be the conditions at which structural failures in the launch vehicle are predicted to occur. The pitch-up command is implemented between 27 and 90 seconds after lift-off, which includes the entire high dynamic pressure region. To further enhance the separation characteristics, the PACS is programmed to provide a short-duration, hardover rate command in pitch and yaw followed by rate damping about all axes until PACS burnout. The crew manually changes the PACS mode selection at Mode A/B switchover. Figure 3-2 illustrates typical Mode B escape trajectories.

3.2 Safe Escape Criteria - Launch vehicle failures that result in mission abort and require spacecraft escape can occur during the final countdown, at ignition, or after lift-off. Pad aborts, those occurring prior to lift-off, are all similar with respect to the initial conditions from which the spacecraft starts the escape. Hence, in the pad abort analyses to date, only single SRM ignition failures have been considered.

The malfunctions considered in the analyses of aborts after lift-off fall into two categories, divergent and nondivergent. Divergent malfunctions are those that induce angular motions in the launch vehicle. This type includes single SRM case burnthrough, loss of Thrust Vector Control (referred to as TVC null), and nozzle failures. Two burnthrough conditions are considered in the analyses, both located so as to produce maximum moments in the pitch plane, one

MODE B ABORT TRAJECTORIES

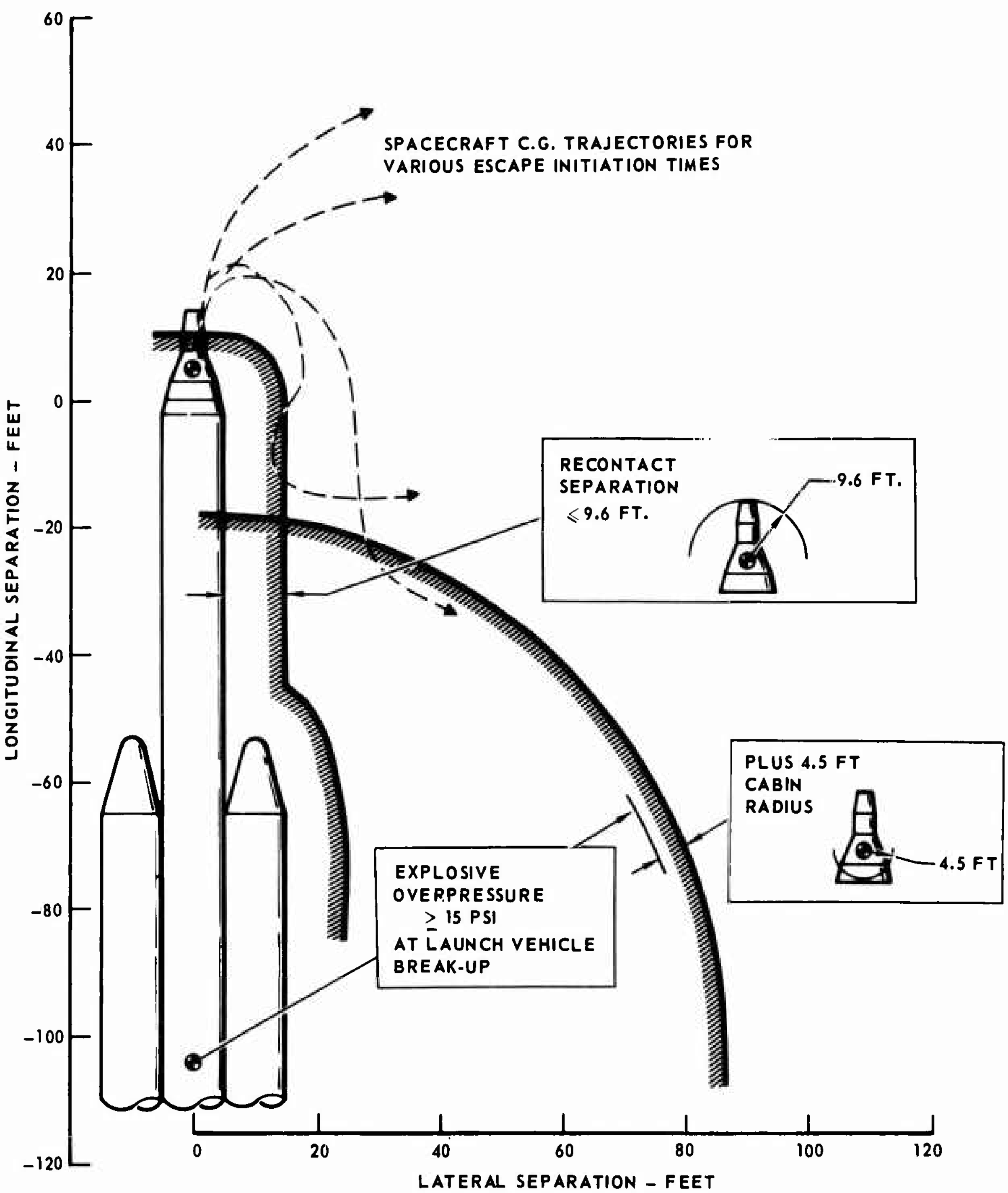


FIGURE 3-2

3.2 (Continued)

causing pitch-up divergence (which augments the pitch command at thrust termination) and the other causing pitch-down divergence (which opposes the pitch command at TT). In a TVC null failure, complete control of one SRM is lost. The null failure can also be considered a nozzle failure since the Martin Company, in modeling the failure, assumed it was caused by a nozzle fracture that destroyed the TVC ports. Nondivergent malfunctions do not induce angular motion and are referred to as straight-ahead failures. Any malfunction can fall into this category if it does not induce moments, however, those analyzed assume that there is no immediate loss in launch vehicle performance and that an abort decision is due to a malfunction in an upper stage (e.g., Stage I or II fuel or oxidizer leak leading to an imminent tank failure).

After the decision has been made to abort the mission three actions must be successfully accomplished before a safe escape is assured (assuming all spacecraft systems function properly): (1) SRM thrust termination, (2) escape initiation, and (3) initiation of crew recovery. The timing of each action is critical to varying degrees depending upon the time of abort and the type of malfunction. Definition of these timing requirements establishes the safe escape criteria.

3.2.1 <u>SRM Thrust Termination Timing</u> - Thrust termination for all Mode A and Mode B aborts during Stage "0" can be automatically performed by the launch vehicle MDS except for straight-ahead malfunctions that the crew detects from the tank pressure gages in the spacecraft. The crew may lock out the auto TT system at any time but current procedures require its use for pad aborts. For the tank leak failures, the timing of thrust termination is critical with respect to the conditions required to maintain structural integrity of the tank and with respect

3.2.1 (Continued)

to the vagaries of the leaks which may not always require aborting the mission. In general, there is adequate anticipation and warning time for the crew so that this task is not considered exceptionally demanding. Martin Company discusses the abort decision criteria in Reference (1).

Manual thrust termination is accomplished by advancing the handle of the Abort Controller to the SHUTDOWN position. If a fast divergent malfunction is detected by the MDS the ABORT light on the instrument panel is illuminated and auto TT occurs if it is enabled. When this happens the crewman should immediately advance the abort handle to the SHUTDOWN position in preparation for the next step in the escape sequence.

3.2.2 Escape Initiation Timing - Escape initiation is manually performed by the crew for all Stage "O" aborts by advancing the handle of the Abort Controller from the SHUTDOWN position to the ABORT position. For Mode A aborts, single SRM ignition is detected and termination initiated automatically before tip-over on the pad can occur; the retro-rocket thrust is always sufficient to provide positive separation of the spacecraft from the launch vehicle; and malfunction-induced moments on the launch vehicle are small enough that the launch vehicle control system can prevent rapid divergence. The TT ports have a lifetime of approximately 10 seconds after thrust termination, beyond which structural failure of the SRM's is predicted. This represents the only clearly specified limit on time of escape initiation in Mode A, although each situation will present its own contingencies for the crew's judgement.

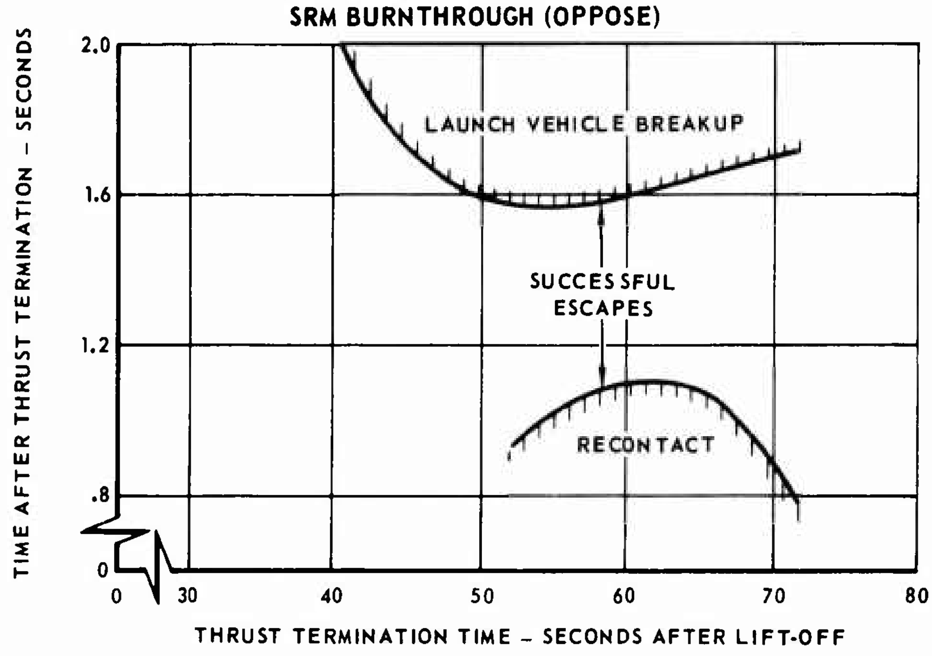
In the Mode B abort situation, timing of the escape initiation is the single highly significant crew function in achieving successful escape. As discussed in Section 3.1, successful escape is assumed to be possible only during a given time

3.2.2 (Continued)

interval after the minimum delay for decay of the conditions that compromise separation from the launch vehicle, and prior to the time of launch vehicle structural failure. The amount of time within the interval varies with time of abort and is most confining near the time of peak dynamic pressure. Figures 3-3 and 3-4 show these safe escape intervals for the four types of malfunctions previously discussed. The delay after thrust termination, before the interval begins, varies directly with the build-up of divergence rate after TT. Accordingly, the intervals for the augment and opposed burnthrough malfunctions occur, respectively, before and after the interval for the straight-ahead malfunctions which have no failure-induced moments. The TVC null, on the other hand, has only one SRM capable of responding to the pitch-up command at TT and therefore diverges slowest of all, taking the longest time to reach the safe escape interval. In order to accommodate these variable times to reach the safe escape intervals, the crew must have a cue to indicate when to advance the handle to the ABORT position. The cue is provided by the correlation between rate of launch vehicle divergence and time of safe escape initiation. By activating the RATE light on the crew console at a pre-selected, launch vehicle-sensed, overrate threshold a positive indication of when to initiate escape is provided. Figure 3-5 shows the escape initiation interval, now identified as the escape action window, as a function of time after the RATE light. All four types of malfunction are shown for two selections of the overrate threshold, 5.5 and 8.0 degrees per second.

3.2.3 Crew Recovery Timing - After escape initiation during a Mode A abort the crew must eventually eject from the spacecraft by pulling the D-ring on the ejection seats. An analysis was performed to establish the sensitivity between

MODE B ABORTS
SAFE ESCAPE CRITERIA



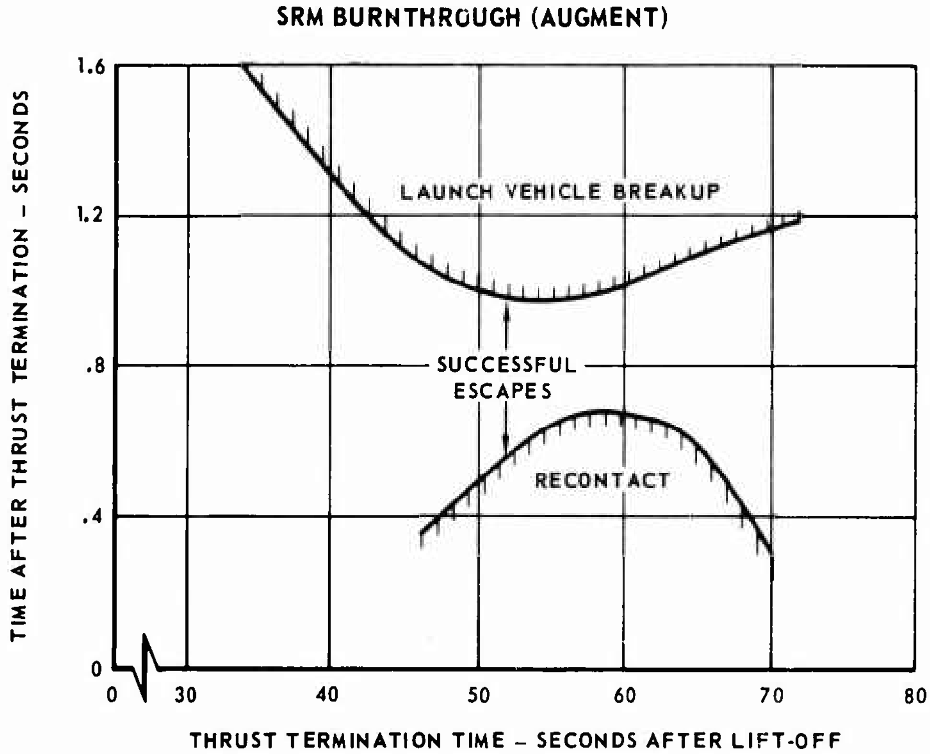
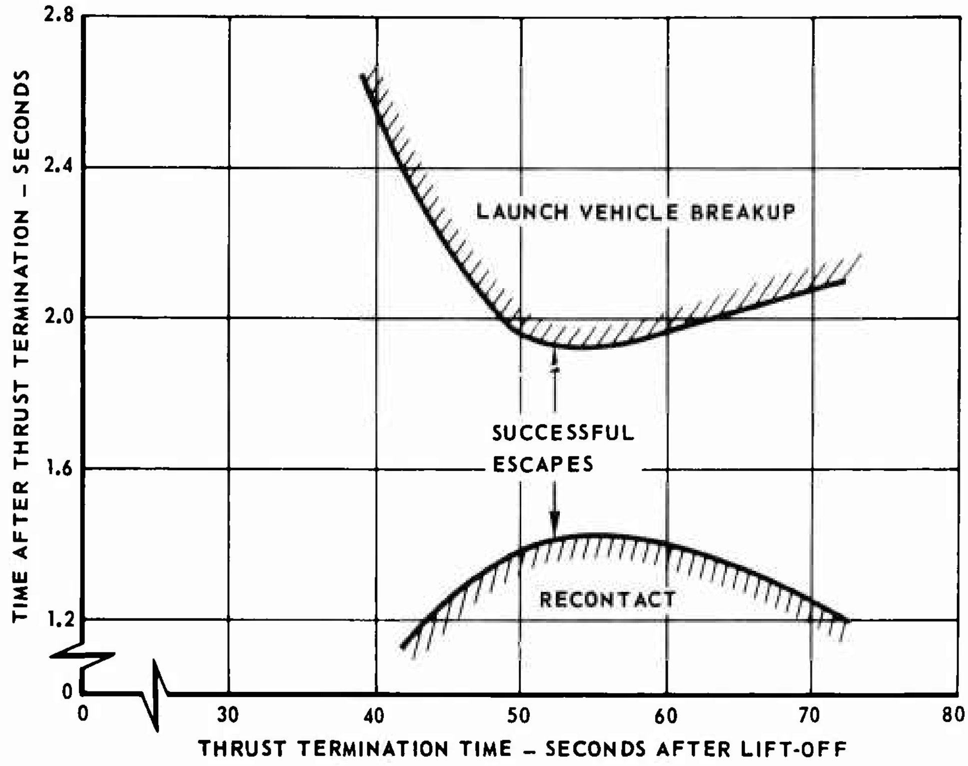


FIGURE 3–3

MODE B ABORTS
SAFE ESCAPE CRITERIA
TVC NULL MALFUNCTIONS



STRAIGHT AHEAD MALFUNCTIONS

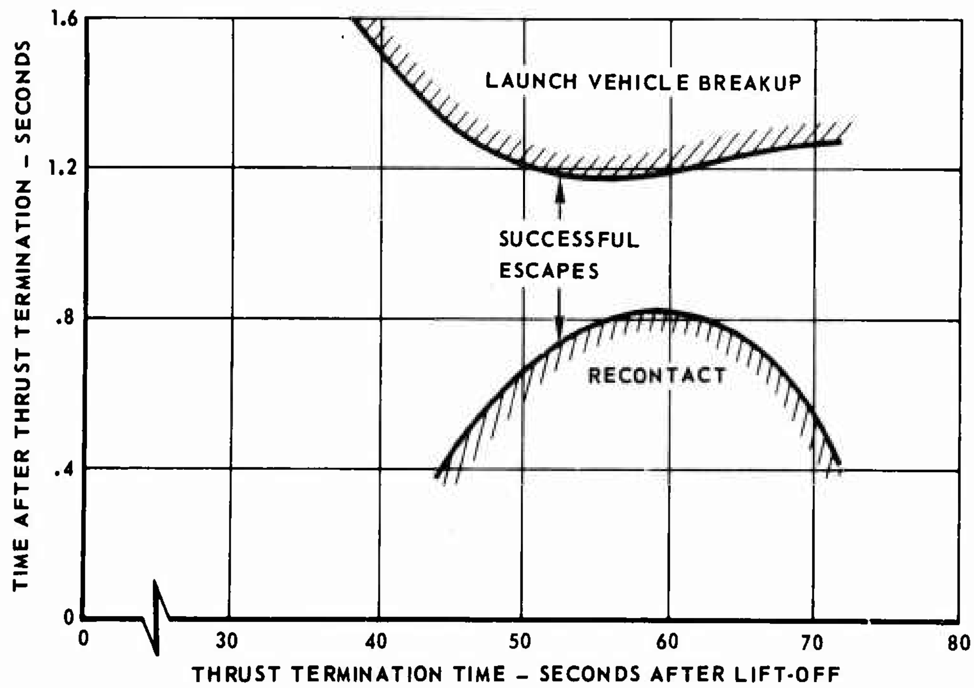


FIGURE 3-4

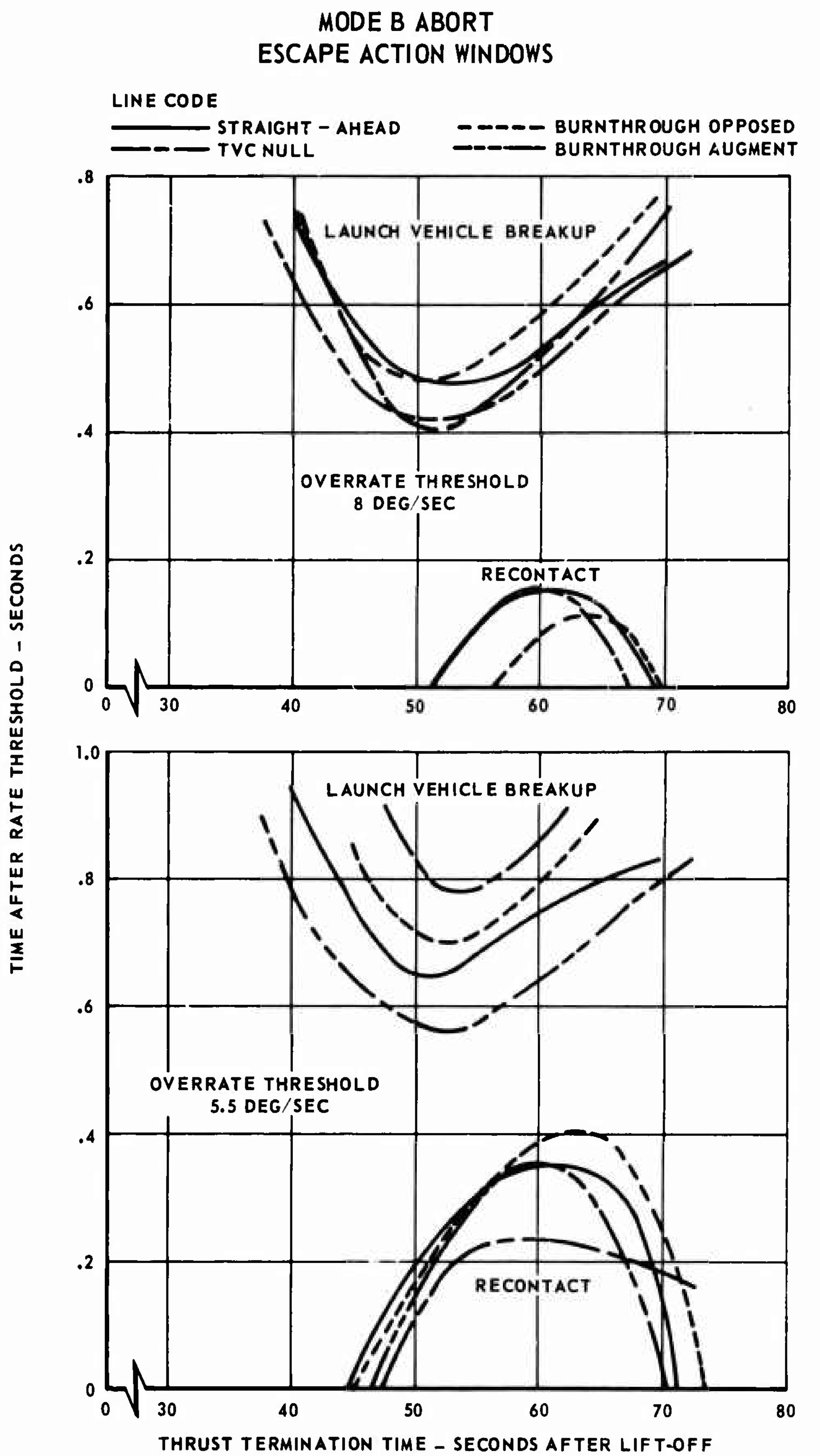

MODE B ABORT
ESCAPE ACTION WINDOWS
LINE CODE
STRAIGHT - AHEAD
TVC NULL
BURNTHROUGH OPPOSED
BURNTHROUGH AUGMENT
LAUNCH VEHICLE BREAKUP
OVERRATE THRESHOLD
8 DEG/SEC
RECONTACT
LAUNCH VEHICLE BREAKUP
OVERRATE THRESHOLD
5.5 DEG/SEC
RECONTACT
TIME AFTER RATE THRESHOLD - SECONDS
THRUST TERMINATION TIME - SECONDS AFTER LIFT-OFF

FIGURE 3-5

3.2.3 (Continued)

time of ejection and achievement of successful recovery. The analysis was performed for pad aborts and consisted of a "Monte Carlo" error and dispersion study that allowed for all meaningful escape trajectory variables up to the time of ejection. Figure 3-6a shows the results of this analysis applied to a range of ejection times. One hundred percent safe escape can be achieved for ejections in the 1.0 second interval between 5.8 and 6.8 seconds after escape initiation. Figure 3-6b applies this 100 percent interval to all Mode A escapes, and thus becomes the escape action window that defines the primary Mode A safe escape criteria. As explained in Section 3.1, the minimum range requirement for parachute deployment exists throughout Mode A, whereas the altitude requirement for parachute stabilization is progressively easier to meet as the abort altitude and velocity increase with time after lift-off.

The actions required following a successful Mode B escape separation, prior to and including recovery system deployment, are presently being analyzed to produce a firm recommendation for time sequencing. Preliminary studies of these actions have not suggested that critical safe escape criteria will evolve.

3.3 Test Program Development - Until now, crew safety studies have been limited to analyses of launch vehicle and spacecraft performance and no satisfactory data were available to show that proposed abort procedures and crew response capability would permit adequate open-loop achievement within the defined safe escape criteria. The subject study, therefore, was decided in order to answer the basic question of whether or not the required abort/escape procedures and crew response capability were compatible. In addition, the response time data obtained would be used to construct a reaction time model for the flight crew which could be used in future analyses. The MOL/SPO contracted to configure

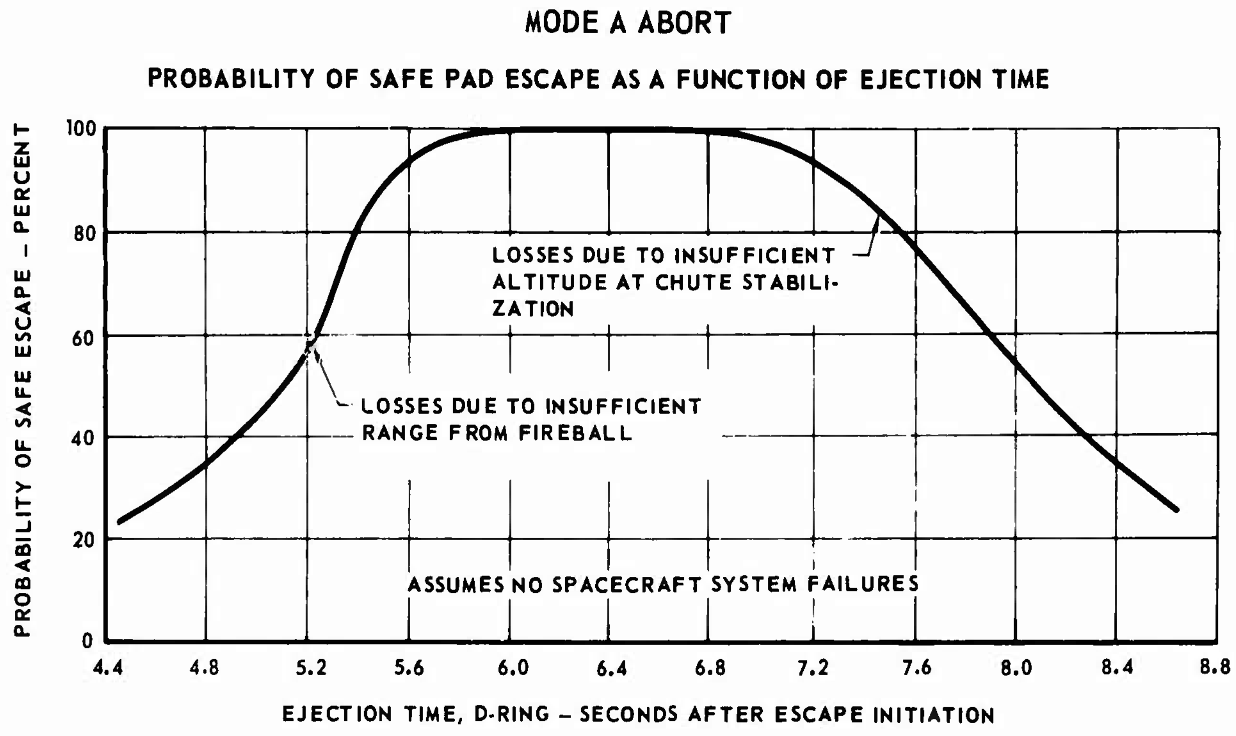


FIGURE 3-6 a

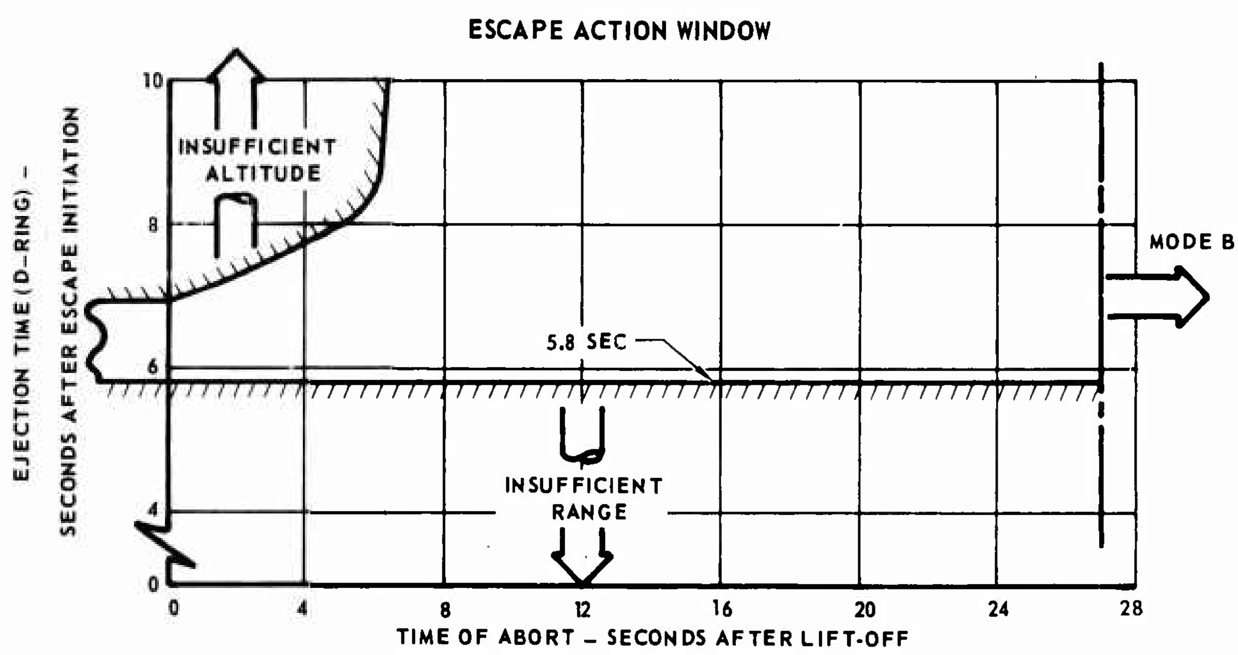


FIGURE 3-6 b

3.3 (Continued)

the LTV moving-base simulator with the NASA Gemini simulator gondola, modified to partially represent Gemini B. The simulator base and crew displays are driven by a real-time, open-loop, six-degree-of-freedom computer program. All Gemini B/Titan IIIM monitoring displays pertinent to Stage "0" aborts are included in the gondola. Mathematical models of the spacecraft (Reference (2)) and launch vehicle were provided by McDonnell Astronautics Company and the Martin Company, respectively, and LTV prepared an integrated program from these models (Reference (3)).

A basic list of 80 abort-forcing and 16 non-abort-forcing malfunctions was prepared by the Contractors (Table I, Appendix A). The selections were made to cover as thoroughly as possible the types and times of abort and display situations that could confront the crewmen. The situations were limited, however, to cases that had been analyzed by Martin and/or McDonnell and for which the success of the escapes could be verified. The Mode A simulations included variations in wind azimuth and velocity, while the Mode B simulations used only the nominal Martin ascent wind profile. Most of the divergent malfunctions were simulated in Mode B with the launch vehicle roll control feedback loop in the autopilot operative after thrust termination, and only a limited number were run with roll control locked out. This lock-out feature is now baseline; however, only a limited analysis of this feature was completed prior to the test. Subsequent analysis (Section 7.2) has shown the LTV simulation results to be independent of whether the roll control is included or not.

For the collection of engineering data, the test program was divided into primary and secondary objectives. The primary objective was to establish crew escape action characteristics for the present abort procedures, and then to repeat

3.3 (Continued)

the test program with alternate escape action cues. For Mode A the ejection timing is presently accomplished without a discrete cue; the alternate, therefore, was to add an EJECT light. As presently implemented in Mode B, the RATE light comes on at a pitch overrate threshold of 5.5 degrees/second beyond the nominal ascent pitch rate program. At this setting, the center of the escape action window occurs approximately 0.5 seconds after the threshold rate is reached (Figure 3-5). The crew response requirement is such that they must deliberately delay their action after recognizing the RATE light in order to reach the abort position within the escape action window. The alternate for Mode B, then, was to delay the RATE light time by increasing the overrate threshold, thus permitting the crew to respond immediately.

The secondary objective of the engineering runs was to evaluate the crew displays. This objective was served, in part, by the subjective display evaluation by both crewmen and test observers that continued throughout the program. In addition, a special set of Mode B simulations was scheduled to specifically evaluate the use of the Flight Director Indicator (FDI) rate needles as a back-up to the RATE light in the event of a malfunction that precluded the issuance of the overrate signal. During these simulations the rate needles were set on high rate which was erroneously mechanized at 15 degrees/second for pitch and yaw. In the spacecraft, the high rate setting produces full deflection at 10 degrees/second for pitch and yaw and 15 degrees/second for roll. The low rate setting produces full deflection at 5 degrees/second for all axes. The runs were performed both with and without the RATE light operative in conjunction with the alternate (higher) rate threshold value.

3.3 (Continued)

In addition to these basic data runs, provisions were made to record static response time for all the crewmen. These data recorded the D-ring and abort handle times in response to the lights without motion or display distractions. These data were intended to be used as an aid in correlating the dynamic data and to help establish the limit of crew response time capabilities.

It was agreed that a total of six crewmen, each completing the 180 runs for the primary objective, and four crewmen, each completing the 32-run secondary objective program, would be an adequate sample to be representative of the full complement of MOL crewmen. Martin Company provided the conditions and display indications related to each malfunction and defined the criteria for abort decisions (Reference (1)). McDonnell Astronautics Company provided the subsequent criteria for successful escape initiation from each malfunction condition, together with recommendations for noise simulation and voice communication (Reference (4)).

4. SIMULATION FACILITIES

4.1 Computer - The LTV facility includes a hybrid, digital-analog, computer system that computes in real time the six-degree-of-freedom trajectory and vehicle dynamics, and generates drive signals for crew console displays, gondola motion, and noise generation. The computer was programmed to simulate a normal Stage "O" flight up to and including ignition of the Stage I engines, and any of the several Stage "O" launch vehicle malfunctions could be selected and simulated by appropriate input data. The program was "open-loop" and could accept input from crew functions in the gondola to initiate simulation of the abort events. Generally, less than five minutes were required to reinitialize between simulation runs. All runs began at SRM ignition. For Mode A aborts the simulation terminated when the ejection seats left the spacecraft and for Mode B it terminated at spacecraft separation from the launch vehicle. Primary data recording was performed with a computer-controlled digital line printer.

The only compromise in the computer programming was to accommodate the 50 millisecond computation cycle limit required to complete all program loops and still maintain the input rate to the analog computer for real-time simulation. Because of this, the various computer tests for event initiations could lag by some fraction of 50 milliseconds. This, however, has not significantly influenced the results since all time-critical response data are referenced to the computer-generated cues (or displays) and not to the programmed values. This was not apparent to the crewman and could not influence his response.

Both Martin Company and McDonnell Astronautics Company supported LTV during the pretest computer program check-out until the launch vehicle and spacecraft trajectory and motion computation gave acceptable duplication of the digital computer simulations previously performed for crew safety analyses.

4.2 Crew Station

4.2.1 Gondola Motion Response - The analog computer output in the form of gondola motion was far from an exact duplication of the actual ascent motions. However, the shortcomings are an inherent part of ground simulation. The simulator base is restricted to angular motion and only limited translational simulation can be achieved by eccentric mounting of the gondola in the gimbals. The three translational and three rotational accelerations are produced by means of a four-gimbal system. The gross pitch gimbal, with a maximum displacement of 100 degrees, is driven as a function of longitudinal (axial) acceleration and, in effect, uses gondola attitude to vary the orientation of the gravity force vector acting on the crew, thus simulating "g" build-up or tail-off. The yaw and inner pitch gimbals are pivoted six feet behind the gondola, the roll gimbal pivots on the gondola longitudinal axis, and each has a displacement of ±10 degrees. (All displacements are referenced to a heads-up, horizontal attitude.) Yaw motions are generated as a function of spacecraft lateral and yaw angular accelerations, the inner pitch gimbals are driven as a function of spacecraft normal and pitch angular accelerations, and roll is generated as a function of roll angular acceleration. The attitude history during a particular simulation case is entirely preempted by the requirements for simulation of these accelerations. However, even with these restrictions, the resultant "ride" has been judged to be a satisfactory simulation and training exercise by experienced simulator personnel and crewmen of both the NASA Gemini and MOL Programs.

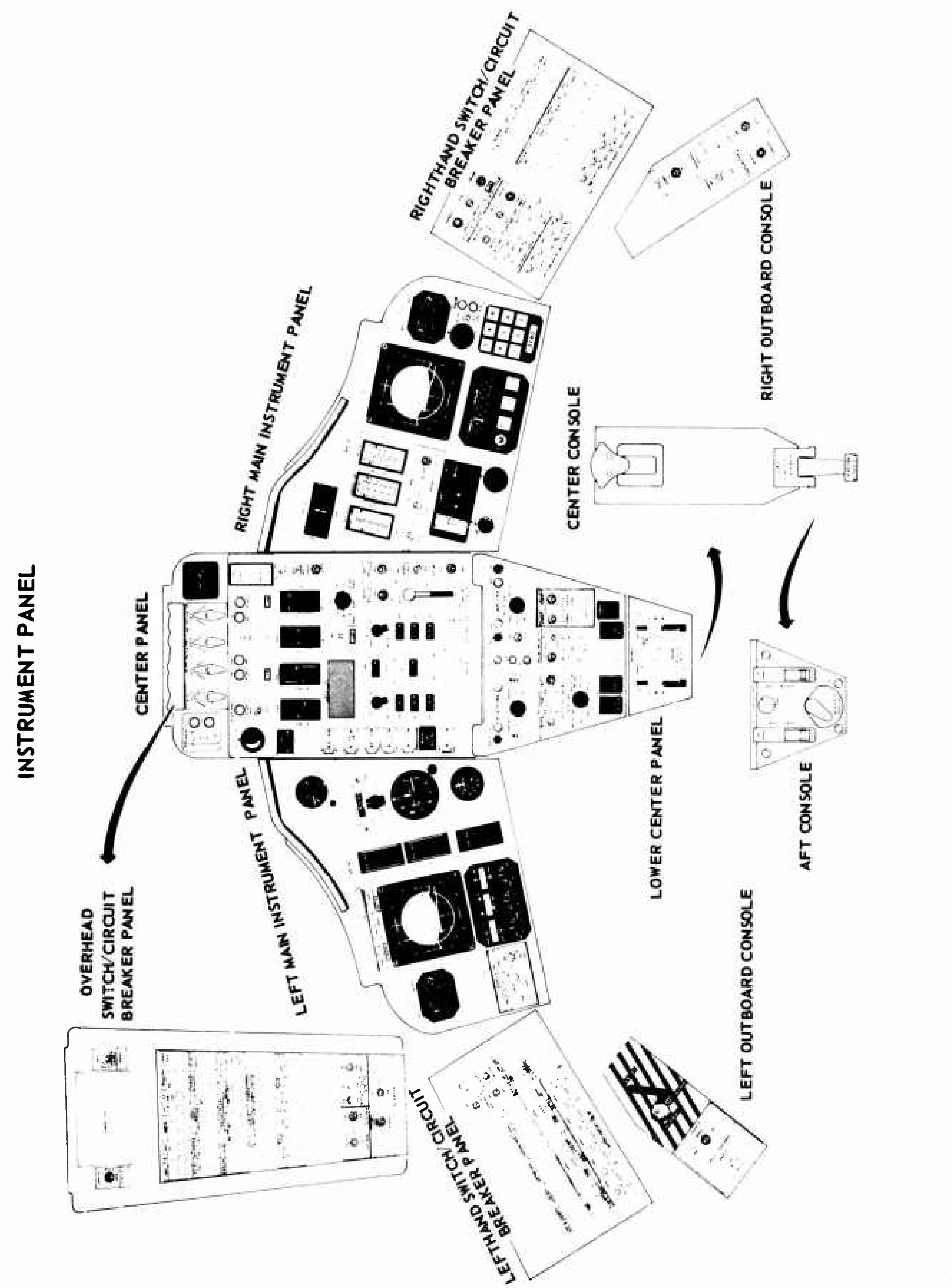
4.2.2 Environment - In order to enhance the simulation, it was desired to provide in the crew station as many of the environmental factors that will act as distractions during ascent as possible. The facility has a sky-horizon projector, but because the computer memory was saturated this feature could not be employed,

4.2.2 (Continued)

and the windows were simply covered with an opaque material. Voice communications were used during each run by the test conductor to countdown prior to launch, and subsequently to call out 10-second time hacks and the various normal ascent events. The crewmen were instructed to acknowledge these communications and report display status regularly. Background noise was also provided. McDonnell recommended the noise levels (Reference (2)) which were estimated with limited data from the NASA/GT-2 mission and the MOL/HST mission. These data sources, however, did not include retro-rocket salvo fire or the SRM thrust termination noise and therefore the LTV implementation of these effects with noise level variations is basically unqualified by experience. The noise is simulated by a high-fidelity speaker system in the dome surrounding the gondola. The basic audio frequencies are produced by tape recorder with the computer controlling the amplitude as a function of thrust levels, flight time and events, altitude, and Mach number.

4.2.3 Controls and Displays - The LTV abort simulator used the NASA Gemini gondola modified to closely represent the Gemini B abort displays and instrumentation. Additionally, some items of equipment were installed in the crew station which were not functional with the simulation. A review of the Gemini B instrumentation as depicted in Figure 4-1 will clarify these items.

Groundrules established for the simulation made provision for single crewman runs. Thus, the left main panel and the left outboard console would provide all of the instrumentation and displays required for abort simulation. Right-hand seat functions such as PACS Mode and PACS Program switches were controlled from the test console to simulate a right-hand crewman. All other displays that were incorporated in the NASA gondola remained unchanged.



INSTRUMENT PANEL
RIGHTHAND SWITCH/CIRCUIT BREAKER PANEL
RIGHT OUTBOARD CONSOLE
RIGHT MAIN INSTRUMENT PANEL
CENTER CONSOLE
CENTER PANEL
LOWER CENTER PANEL
AFT CONSOLE
OVERHEAD SWITCH/CIRCUIT BREAKER PANEL
LEFT MAIN INSTRUMENT PANEL
LEFTHAND SWITCH/CIRCUIT BREAKER PANEL
LEFT OUTBOARD CONSOLE

FIGURE 4-1

4.2.3 (Continued)

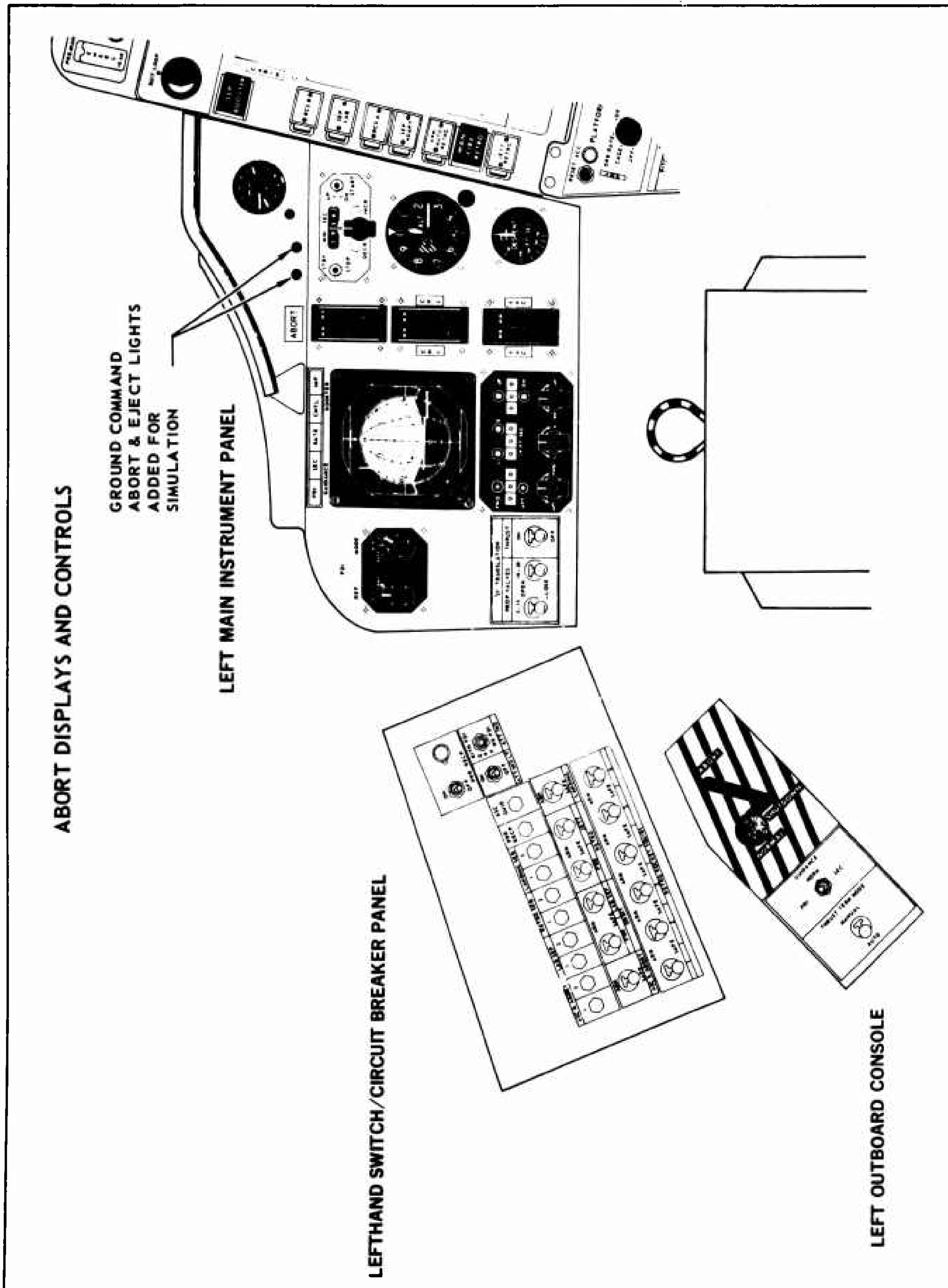
Left Main Instrument Panel - Functional instrumentation on the left main panel included the following as illustrated in Figure 4-2.

Guidance and Launch Vehicle Status Lights - Operation of these lights was limited to abort considerations. Launch vehicle RATE and IMPulse lights were functional. A provision was included in the program for selecting a variable rate threshold on the RATE light. PRImary and SECondary guidance lights and the Launch Vehicle CoNTroL light were not functional. An additional light was installed on the main panel above the FDI mode selector switch which was to provide a ground command guidance switchover indication. This light was not functional during the simulation, however.

Light locations on the panel were somewhat different from Gemini B due to using the NASA Attitude Ball location. This positioned the lights 1/2 inch higher than they will be on the Gemini B panel.

Attitude Ball - The attitude display used in the simulation was a late model NASA Gemini instrument that incorporated the one degree scale calibration on the spacecraft pitch scale. This is representative of the Gemini B instrument and is well suited for use in the simulation. Location of the display on the panel utilized the same mounting hole as the NASA display which positioned the ball 1/2 inch higher than its normal location on the Gemini B panel. The Flight Director needles were operational and displayed vehicle rates during ascent.

Launch Vehicle Instrumentation - Launch vehicle instrumentation was established for the simulation using the latest data available from the Martin Company at the time of modification of existing NASA meters by the supplier. An illustration of the curves used for meter calibration and the



ABORT DISPLAYS AND CONTROLS
GROUND COMMAND ABORT & EJECT LIGHTS ADDED FOR SIMULATION
LEFT MAIN INSTRUMENT PANEL
LEFTHAND SWITCH/CIRCUIT BREAKER PANEL
LEFT OUTBOARD CONSOLE
ABORT

FIGURE 4-2

4.2.3 (Continued)

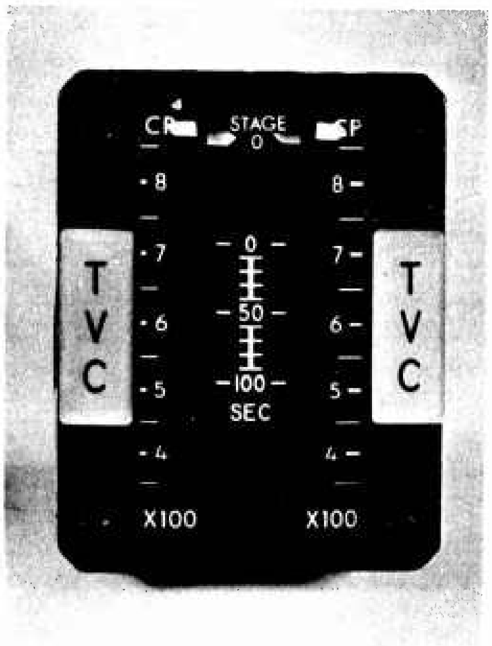
corresponding meter faces are shown in Figures 4-3, -4, and -5. All three launch vehicle meters were functional with the inner and outer needles driven by separate inputs to permit simulation of bus failures. Likewise, all other items connected to these separate electrical busses were operational. As an example, if the electrical bus supplying the center needles failed, the center needles on all three meters failed to the top of the scale. Redundant lamps in the TVC and CH lights also were extinguished. This simulates to the crewman a failure case that does not require abort action.

Abort Light - This light was operational and was illuminated by the computer simulation of auto TT or when the abort handle was manually moved to the SHUTDOWN position. An additional ground-controlled abort light was added to the main instrument panel adjacent to the MDS-controlled light. This light was installed to provide an additional cue that could be used to evaluate crew response.

Event Timer - This instrument was the NASA Gemini event timer which can be used to count either up or down on command and digitally displays elapsed time in minutes and seconds. This instrument is resettable by the crewman.

Abort Console - Abort handle provisions were identical to NASA Gemini and Gemini B installations. The SHUTDOWN and ABORT position switches provided the timing function to the computer for establishing crew reaction time during the abort situation simulated. The guidance switchover and automatic thrust termination switches were not functional. Figure 4-6 provides a detail description of the functions of the abort handle.

STAGE "0"
METER FACE AND CALIBRATION CURVES



PRESSURE HISTORY FOR SEVEN SEGMENT 120-INCH MOTOR

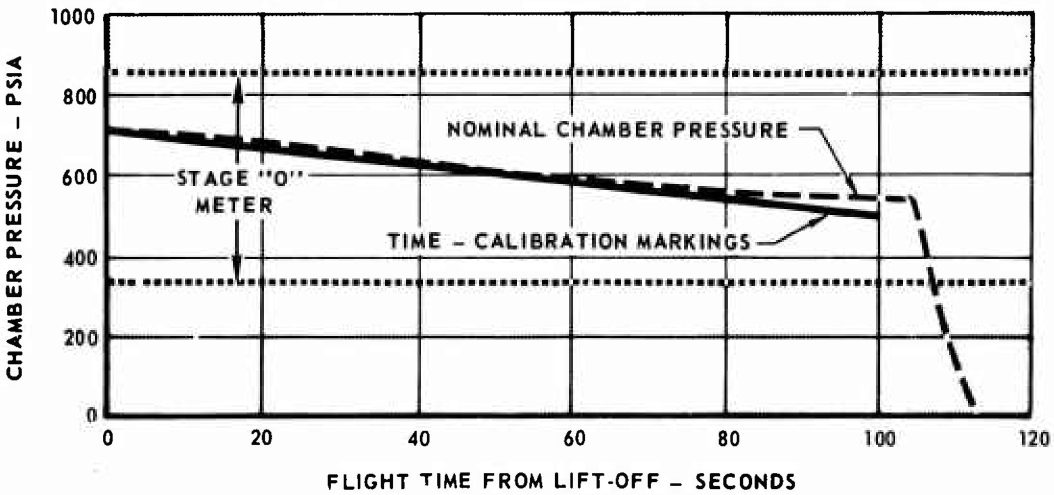
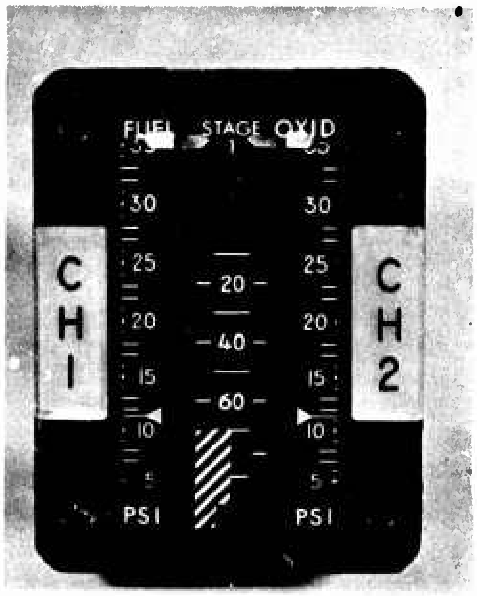


FIGURE 4-3

STAGE I
METER FACE AND CALIBRATION CURVES



TANK PRESSURES REQUIRED FOR STRUCTURAL INTEGRITY

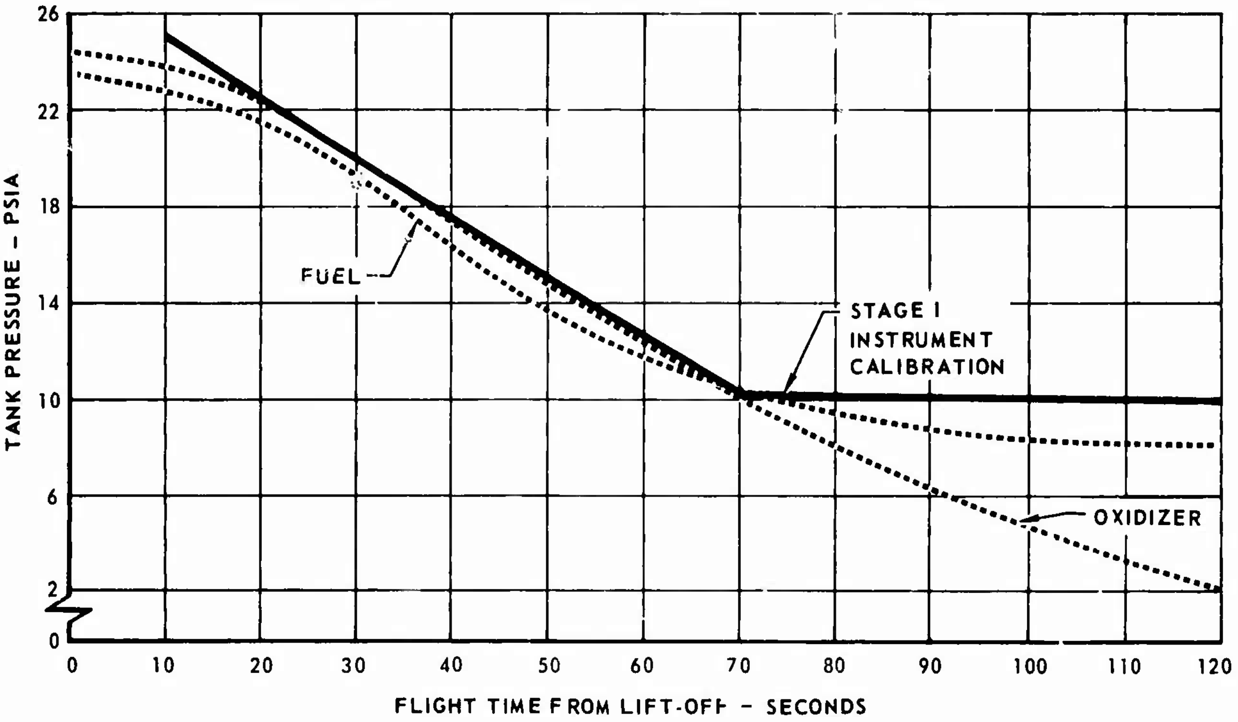
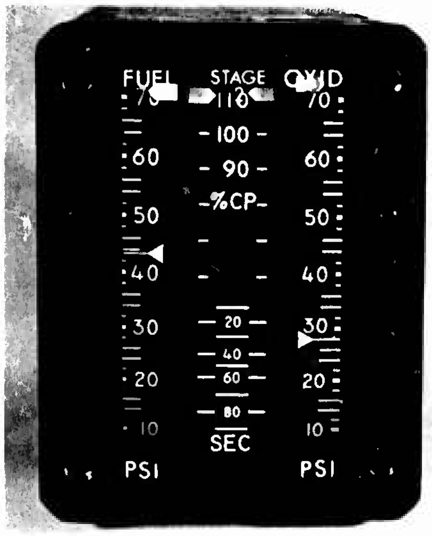


FIGURE 4-4

STAGE II
METER FACE AND CALIBRATION CURVES



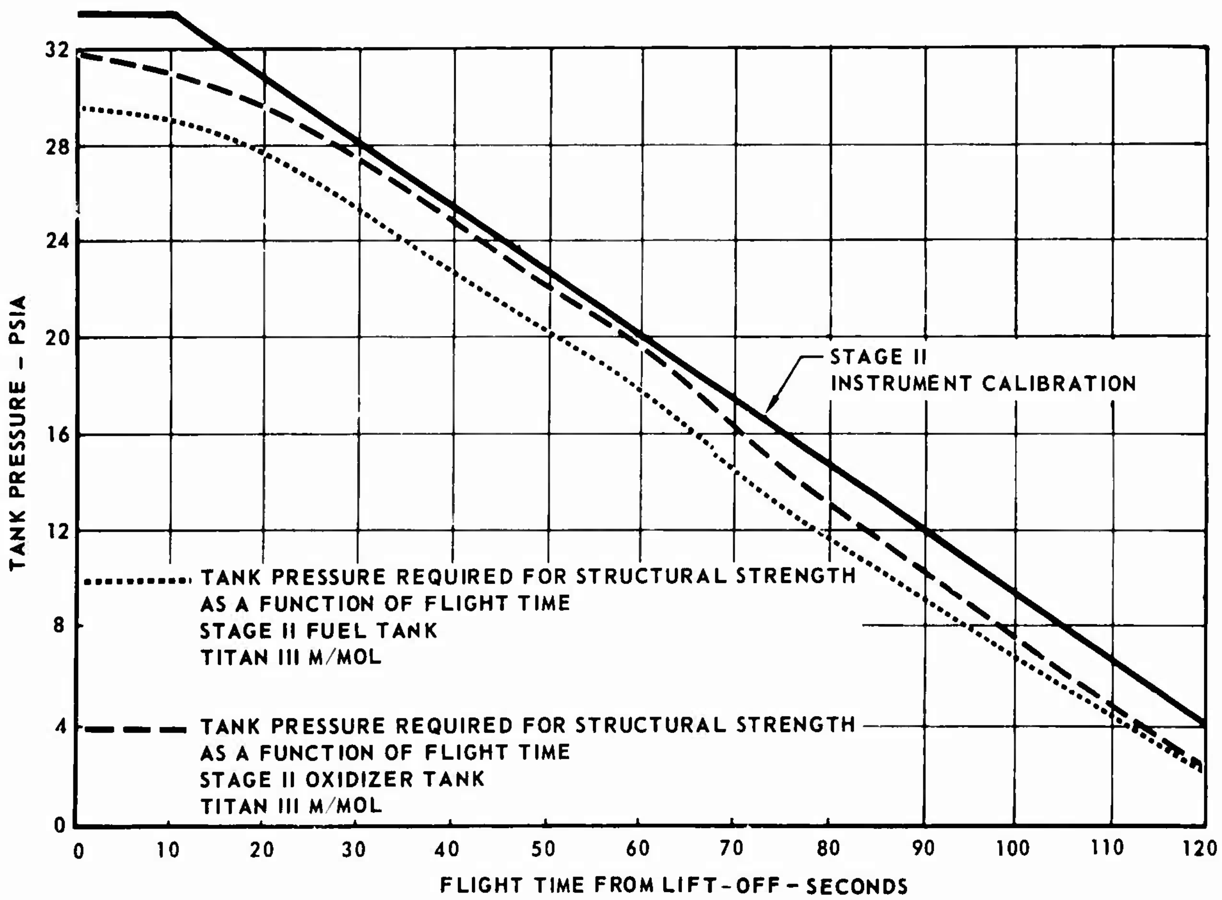
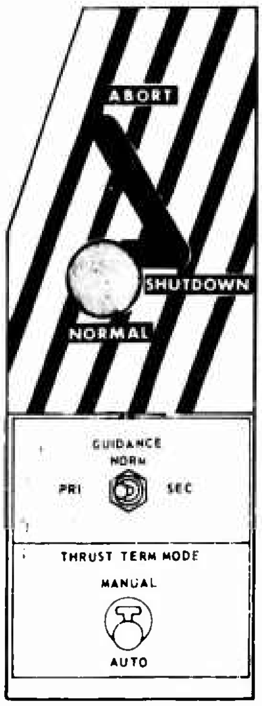


FIGURE 4-5

ABORT CONSOLE



LEFT OUTBOARD CONSOLE

HANDLE POSITION	FUNCTIONS PERFORMED
NORM	NONE
SHUTDOWN	SENDS ENGINE CUT-OFF COMMAND TO THE TITAN IIIM AND T/M SIGNAL TO GROUND.
ABORT	FIRES THE NORMALLY CLOSED RCS A & B FUEL, OXIDIZER, AND PRESSURANT SQUIB VALVES, ARMS THE ORBIT POWER SQUIB BUS AND RETRO POWER SQUIB BUS ACTIVATES PAD ABORT CONTROL SYSTEM, FIRES PYRO DEVICES WHICH DISCONNECT AND SEVER WIRES & TUBING BETWEEN EQUIPMENT AND RETRO SECTIONS, FIRES SHAPED CHARGES WHICH SEPARATE THE EQUIPMENT SECTION FROM THE RETROGRADE SECTION, AND FIRES THE RETRO ROCKETS IN SALVO. THE RCS A & B ATTITUDE CONTROL SWITCHES, IF IN THE OFF POSITION, ARE BYPASSED, EFFECTIVELY PUTTING THEM IN THE ACE POSITION.

FIGURE 4-6

4.2.3 (Continued)

D-Ring - The ejection seat D-ring was used to furnish timing of the start of ejection sequence. The D-ring was utilized only for Mode A abort situations. An additional light was incorporated in the simulator and was called the seat EJECT light. Provision for illuminating this light six seconds after initiation for Mode A aborts was incorporated in the computer program. This light was positioned along with the ground-commanded abort light next to the MDS-controlled ABORT light on the left main instrument panel.

5. FLIGHT CREW PARTICIPATION

5.1 General Aspects - As used in discussing the simulation results, "crew" and "data" are collective references to the total output of the six MOL crewmen who participated in the tests. The data are felt to be representative of the performance of the full complement of MOL crewmen since a fair sample of age, experience, and physical characteristics was included in the test group. Also, the observed variations in the techniques and methods used to accomplish the common set of procedures were sufficient to lend confidence to the fidelity of the sample. For instance, in gauging the time delay for ejection during Mode A aborts, some individuals relied completely on kinesthetic cues from retro-rocket burnout (noise level change and decrease in acceleration), while others counted seconds, referred to the event timer, or combined the use of several cues. In gauging the Mode B delay prior to escape initiation, such techniques as pronouncing a word after seeing the RATE light, or a deliberate wait until the word RATE could be read on the face of the light unit were used. This degree of crew-induced variability in the data is desirable because there will always be some variation among crewmen, and this must be allowed for in the engineering model of crew performance.

For the simulator runs the crew wore light flight suits, used lap belts only, and wore a standard head-set for communication. A limited amount of data was recorded prior to the first engineering data runs for the purpose of evaluating the need to provide the crewmen with Pressure Suit Assembly (PSA) gloves. Static trials were performed both with and without a PSA glove and the results (Figure 5-1 and Table XI, Appendix A) have been submitted to a Chi Square statistical analysis which shows that no statistical significance can be associated with the differences in responses with and without the glove. Furthermore, the crewmen

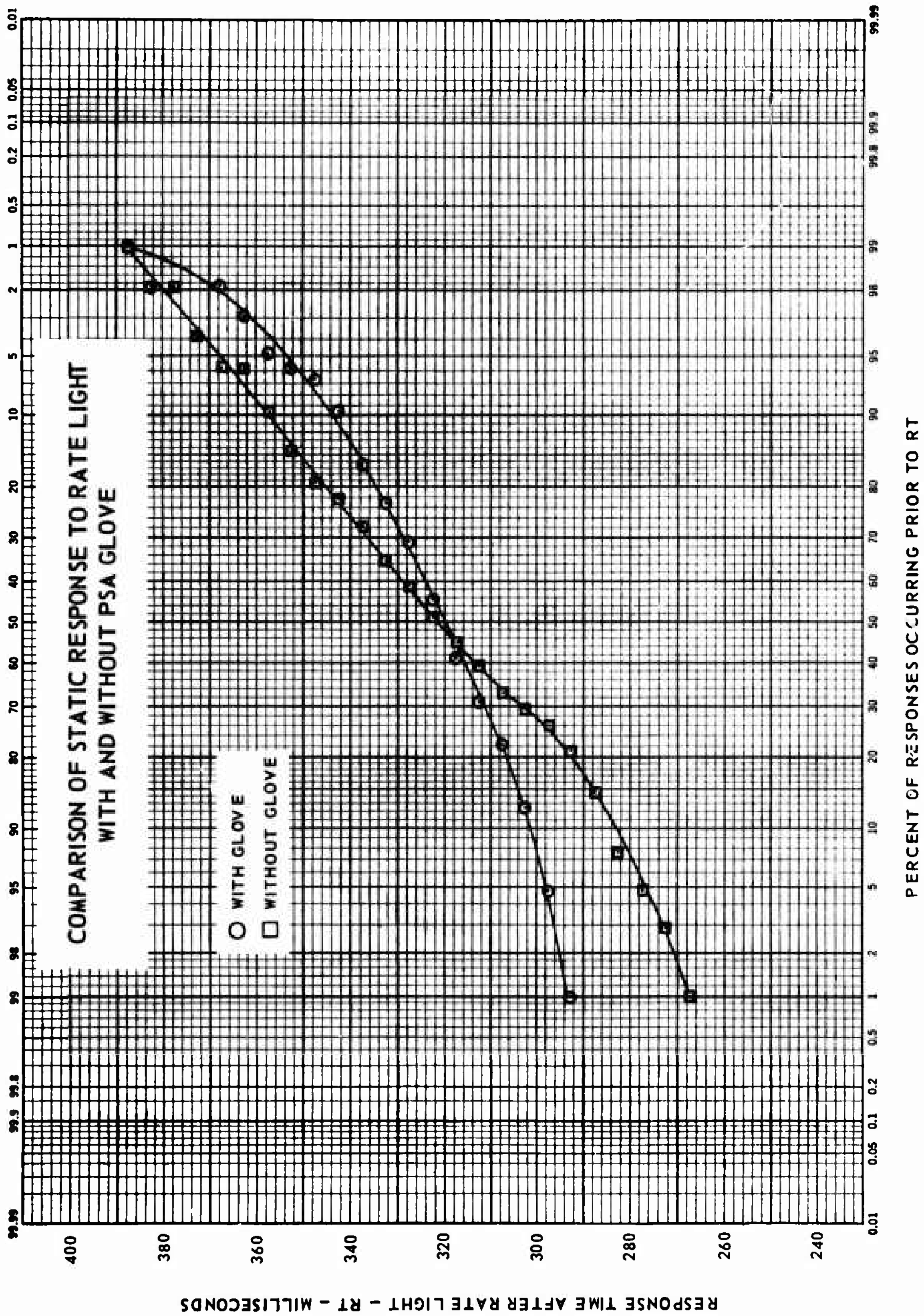

COMPARISON OF STATIC RESPONSE TO RATE LIGHT
WITH AND WITHOUT PSA GLOVE
WITH GLOVE
WITHOUT GLOVE
PERCENT OF RESPONSES OCCURRING PRIOR TO RT
400
380
360
340
320
300
280
260
240
RESPONSE TIME AFTER RATE LIGHT - RT - MILLISECONDS

FIGURE 5-1

5.1 (Continued)

were not satisfied that use of the gloves, without pressurization and the rest of the MOL suit, would give meaningful results. Therefore, all data runs were performed wearing only a light leather glove for comfort and protection of the hand.

Two crewmen were present during each cycle through the complete program which required five days for the primary data, including an indoctrination period, and two days for the secondary data runs. Each data session, between pilot changes, was limited to approximately one hour. Approximately half of the data runs were solo, with the right seat occupied on the other half by visitors and observers concerned with evaluating the simulation.

5.2 Pre-Test Indoctrination - The participating crewmen all had some degree of familiarity with both the Stage "O" abort procedures and the spacecraft/launch vehicle systems which was accumulated from various meetings, crew briefings, mock-up reviews, etc. Some had flown the reentry simulator at McDonnell. In preparation for this program, a crew member was in attendance at all pre-test meetings, and information and documentation from the program definition phase was available to the rest of the crew through this representative. The final pre-test preparation was at a simulation briefing given to the crew at SAMSO Headquarters in Los Angeles by Martin, McDonnell, and LTV. At this briefing an attempt was made to cover all facets of Stage "O" aborts and relate them to the simulation program.

Crew indoctrination was completed after each crewman arrived at LTV for testing. They were given a final review of the cockpit, abort control, and displays. A selection of typical cases from the program run schedule was then simulated with the crewman in the gondola. Each event and significant display indication was explained as it occurred during each case, and the crewman began

5.2 (Continued)

to develop his ability to recognize the abort action cues and achieve the response timing.

The first half of the primary objective program called for use of the escape procedures presently implemented. For Mode A these procedures require the crew to initiate escape as soon as possible following the abort decision, and to subsequently pull the D-ring to initiate ejection as close as possible to 6.3 seconds after escape initiation. The crew were left to their own devices, such as mental timing, referral to the event timer, or pacing their action with respect to the acceleration and noise level changes at retro-rocket burnout, to achieve the desired ejection time. The practice session was continued until the crewman was consistent in responding within the one second safe ejection window between 5.8 and 6.8 seconds after escape initiation.

The Mode B procedure calls for the crewman to achieve safe escape initiation by reaching the ABORT position with the abort handle as close as possible to 0.5 seconds after the RATE light comes on. A safe escape initiation is achieved, regardless of malfunction type, if the spread of response time falls between 0.4 and 0.57 seconds after the RATE light. The goal for Mode B training was, therefore, to converge the responses within this window before start of data runs.

The second portion of the primary objective program called for changes in escape procedures by altering the cues used to prompt crew escape actions. For Mode A an EJECT light was activated 6.0 seconds after escape initiation to serve as a discrete ejection time cue. The choice of 6.0 seconds was arrived at from examination of static D-ring response data that showed a mean time of 0.25 seconds after the EJECT light to accomplish D-ring pull. The target safe ejection window, of course, remains the same and the training with the light

5.2 (Continued)

proceeded similar to that with the earlier procedure.

For Mode B escape it was desired to eliminate the need for deliberate delay after the RATE light comes on. This is accomplished by activating the RATE light at a higher threshold value which, in effect, puts the delay into the RATE light timing and permits the crewman to respond immediately. For this portion of the program the safe escape initiation window is between 0.15 and 0.40 seconds after the RATE light. This RATE light timing was also deduced from the static data which showed mean response times to the RATE light cue from 0.28 to 0.32 seconds.

The final phase of engineering data runs was performed to support the secondary test objective by studying a back-up to the primary Mode B escape initiation procedures. For this phase, the FDI needles were set on high rate which gave a pitch and yaw rate range of 0 to 15 degrees/second. The crew were instructed to mark the FDI cover glass, to use that mark as an index to note achievement of the rate threshold at 8 degrees/second, and to initiate escape based on the FDI cue. For given runs the crewmen did not know whether the RATE light would come on or not (simulating a failed light).

Grasp of the procedures in all test phases was very rapid and the practice sessions consisted mainly of converging the random responses to the various abort situations within the prescribed escape action windows. In general, the time required to indoctrinate the crew to a point of confidence and response consistency was not significantly different among crewmen, with six to eight hours of practice per crewman being typical prior to the initial start of data runs and one to two hours at the points where the procedures changed.

5.2 (Continued)

The usual procedure for converging the response time in the practice sessions was to tell the crewman his results after each run so that he could make appropriate adjustment. Toward completion of training the crewman performed a sequence of runs before being told the response times. During the data runs the crewmen were not given their response times until the end of each one hour session.

6. DATA ACQUISITION

6.1 Basic Simulation Data - Computer output data for the abort simulations were listed in a lengthy on-line printer format which included all pertinent trajectory parameters, display read-out values, and launch vehicle status. These data were recorded at specified time intervals over the duration of each run, as well as at the time of occurrence for specified events. The bulk of the data was intended for computer program check-out and trouble shooting, and for identification of anomalies in runs where the response time data appeared inconsistent or operational problems occurred. Otherwise, the only data of permanent interest were the event times and crew action times. These latter data were hand tabulated from the computer output sheets as each run was completed and kept as a consolidated record. The test cases were presented to the crewmen in a random sequence and, therefore, part of the post-test effort was to both verify the records made during the test and reorganize the data for analysis. The reorganized tabulations are presented in Tables II through VII in Appendix A. For all cases the tables contain common parameters: (1) case number, which identifies the run and related variables (Table I), (2) the time at which the malfunction starts, and (3) the thrust termination time (ABORT light on). These times are recorded to the nearest 50 milliseconds. In addition to the common parameters, the tables of Mode A data include escape initiation time (switch closure at the ABORT position) and the time when the D-ring was pulled. These two items are measured and recorded to the nearest 10 milliseconds. The response time column gives the time difference between escape initiation and D-ring pull. These Mode A data are further separated into two groups containing data for each case performed with and without the EJECT light cue.

6.1 (Continued)

The Mode B data on Tables IV through VII include the time of RATE light activation and the time of escape initiation, measured to the nearest 10 milliseconds, and in the response time column the difference between these two values. These data are also separated into subgroups for each case according to the escape initiation cues. For a few cases, the crewman initiated escape prior to RATE light (negative response time) and no computer print out for the RATE light was available. In these instances the proper time was deduced from similar runs for the same case performed by another crewman. Also, during a portion of the runs using the FDI needles on high rate, the RATE light was inactive. A RATE light print out was still recorded and, as in all other Mode B cases, the response time is given with respect to this event.

For the sake of brevity all other data items, which have only minor bearing on the basic data analyses, are excluded from the tables. The Gemini B Aerodynamics Group at McDonnell Astronautics will maintain informal records of these unpublished data for a limited period and then dispose of them.

6.2 Static Data - Static response time data were recorded for all of the crewmen as an aid in substantiating the basic data analyses, and in the case of the first two crewmen, to provide a basis for the timing of the alternate cues. These data were recorded with the crewman seated in the gondola with the gimbals locked at a slight nose-up attitude and all displays but the light cue inactive. On each static trial the crewman signified that he was ready, and after an arbitrary delay the light cues were automatically presented to him by the analog computer and his response time was recorded to the nearest millisecond. Each crewman performed approximately 25 trials on the D-ring and 25 on the abort handle. Table VIII shows the static response time for the D-ring. Table X gives

6.2 (Continued)

the time to reach the SHUTDOWN position in response to the ABORT light and the subsequent time to reach the ABORT position in response to the RATE light. For the abort handle data the time interval between switch closure at the SHUTDOWN position and RATE light on was randomly varied among delays of 0.35, 0.60 and 1.30 seconds. Another set of data, measured separat[illegible] records the time to reach the ABORT position in response to the RATE ligh[illegible]or a series of trials with the abort handle initially in the SHUTDOWN [illegible]. These data are presented in Table IX, Appendix A.

In conjunction with the static response [illegible] time from SHUTDOWN to ABORT position, the first pair of crewmen tested [illegible]sed to evaluate the possible need to perform the program with a PSA glove Table XI shows these data both with and without the glove.

6.3 Additional Static Data Measured At McDonnell - The static abort handle data recorded at LTV do not include cases for which the RATE light is on prior to the time that the handle reaches the SHUTDOWN position. As the analysis of the simulation data progressed it became of interest to study the influence of this situation in detail. A crew station mock-up was prepared in the McDonnell Human Factors Laboratory and an additional set of static data was recorded. The lab set-up consisted of a Martin-Baker ejection seat and a photographic representation of the left main instrument panel containing active ABORT and RATE light units. The abort handle (the same unit used at LTV) was mounted in its proper position with respect to the seat and the test section was confined by a curtain. Lighting similar to the LTV gondola was simulated in the crew station. Figure 6-1 shows a picture of the test set-up.

MODE B STATIC DATA TESTS
MCDONNELL HUMAN FACTORS LABORATORY TEST SETUP

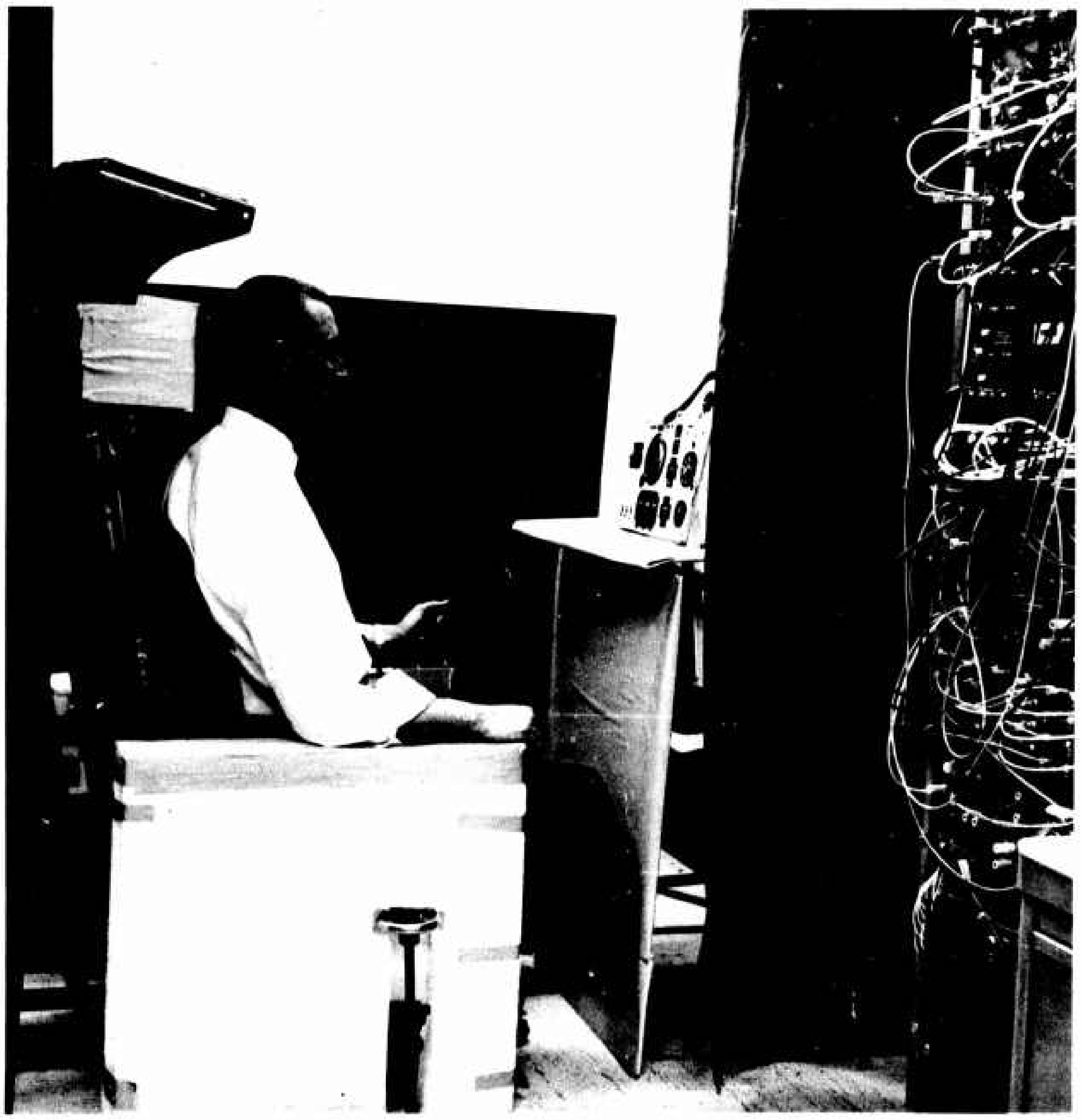


FIGURE 6-1

6.3 (Continued)

A cue-timing and data read-out system of one millisecond accuracy was provided, and the test procedures and crew instructions were the same as those employed in the LTV simulation. Four MOL crewmen participated in this test series and each performed approximately 84 static trials. The data recorded include: (1) time to reach the SHUTDOWN position after the ABORT light, (2) time interval between ABORT light and RATE light, and (3) time to reach the ABORT position after the RATE light. The time interval between the ABORT and RATE lights was the variable test condition and it was spaced at approximately 50 millisecond increments between 150 and 600 milliseconds after the ABORT light. This time interval was randomly selected for the sequence of trials given to each crewman as was the time of ABORT light onset. The resultant data are given in Table XII, Appendix A.

6.4 Data Preparation - A basic manipulation of all the recorded response time data was performed to put them in a form that is suitable for analysis. The procedure is one commonly used in dealing with statistical data. The data are first distributed into "cells" of given time intervals, the size of which is determined by the extremes of the response times and the quantity of data. The number of data points falling into each cell is called the frequency of occurrence (f) for that time interval. Next, a cumulative frequency (cf) is established for each cell by summing the frequency of occurrence, starting at the earliest times, up to and including each cell in turn. The cumulative frequency is then adjusted to give values that can be assigned to the mid-point of each cell (cf_m). This is accomplished in the same way as the cf values, except that only half the occurrences in a cell are added to the sum of all occurrences prior to that cell and that sum is assigned to the mid-point of the cell. Finally, the cf_m values

6.4 (Continued)

are transformed into percentages of the total occurrences by dividing each value by the total number of data points. The percentages are then plotted on standard probability paper as a function of the response time (mid-point of each cell) for which they were derived. The resulting plot is highly descriptive of the response characteristics and a number of deductions can be made by simple inspection. For example, the lower abscissa scale corresponding to a given response time represents the probability of responses occurring prior to that time and the upper scale represents the probability of responses occurring after that time. The median time at 50 percent has equal likelihood of responses occurring either before or after that time. Furthermore, the probability scale is divided according to the normal, or Gaussian distribution, such that normally distributed data will approximate a straight line when plotted on this scale, and a skewed distribution will show a shallower slope at the high density end of its frequency distribution.

7. DATA ANALYSIS

7.1 Mode A Ejection Timing - The ejection timing characteristics measured during the first portion of the simulation program are shown in Figure 7-1. The crew were instructed and trained to pull the D-ring as close as possible to 6.3 seconds after escape initiation. For these runs they used only their ability to gauge the time lapse from the incidental cues available in the crew station. While some crewmen counted seconds or used the event timer as an aid, they all relied to a large extent on the simulated acceleration and noise level changes at retro-rocket burnout, and the data substantiate this. Only about 10 percent of the responses, both on the pad and after lift-off, occur prior to 6.3 seconds. At 6.3 seconds the ejection response curve slopes decrease, indicating greater response frequency and implying the presence of a fairly consistent event in the simulation that is serving as a cue. The ejection responses for pad aborts, for instance, occur with only 10 percent frequency in the 300 milliseconds prior to 6.3 seconds, whereas they occur with 87 percent frequency in the first 300 milliseconds after 6.3 seconds. The retro-rockets burn out between 5.5 and 6.0 seconds after escape initiation. With a reasonable delay for decision and start of response, this event cue would cause the effect seen in Figure 7-1. It was also noted that the bulk of the responses prior to 6.3 seconds was achieved by only one crewman who, more than any of the others, emphasized use of the event timer. The differences in response time distribution between pad aborts and aborts after lift-off exist primarily at the upper extreme of response times. For the pad aborts the crew was aware of the maximum allowable time for safe ejection, while the aborts after lift-off, where the maximum time is not constraining, tend to include some late responses. This latter effect is noted in the data for flight times greater than 12 seconds and is probably due to the

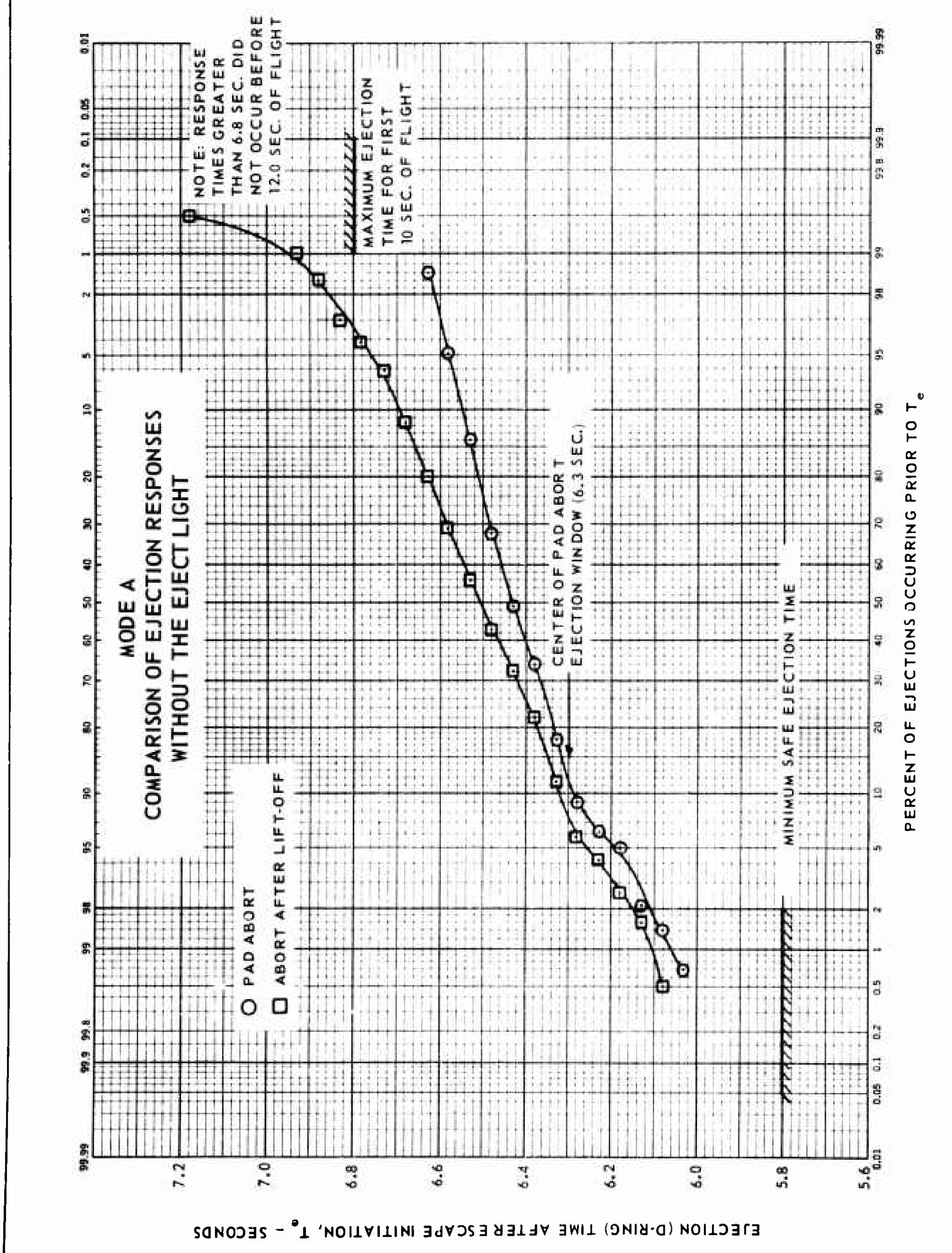

MODE A
COMPARISON OF EJECTION RESPONSES
WITHOUT THE EJECT LIGHT
NOTE: RESPONSE TIMES GREATER THAN 6.8 SEC. DID NOT OCCUR BEFORE 12.0 SEC. OF FLIGHT
MAXIMUM EJECTION TIME FOR FIRST 10 SEC. OF FLIGHT
CENTER OF PAD ABORT EJECTION WINDOW (6.3 SEC.)
MINIMUM SAFE EJECTION TIME
PAD ABORT
ABORT AFTER LIFT-OFF
PERCENT OF EJECTIONS OCCURRING PRIOR TO T_e
EJECTION (D-RING) TIME AFTER ESCAPE INITIATION, T_e – SECONDS
7.2
7.0
6.8
6.6
6.4
6.2
6.0
5.8
5.6

FIGURE 7-1

7.1 (Continued)

increased attenuation with flight time of kinesthetic cues at retro-rocket burnout because of greater spacecraft dynamics after separation and increasing aerodynamic noise levels.

Figure 7-2 gives the basic ejection response characteristics measured in the second portion of the engineering runs. For these runs an EJECT light was illuminated 6.0 seconds after escape initiation. The effect was to reduce the variation in ejection responses to a minimum. There is no longer any difference in response characteristics throughout Mode A and the range of response times for the total sample is reduced by almost 70 percent. Figure 7-2 also shows the static ejection response data (Table VIII) that were used to estimate the activation time for the EJECT light. A median static response time of 250 milliseconds was noted. This was increased to 300 milliseconds to allow for the expected additional delay in the dynamic situation. Applying this 300 millisecond bias to the 6.3-second desired D-ring time leads to the selection of 6.0 seconds for the EJECT light. The actual dynamic displacement was 80 milliseconds, giving a median response time of 6.33 seconds in the data runs.

Figures 7-3 and 7-4 are presented to give a direct comparison of responses with and without the EJECT light for pad aborts and aborts after lift-off, respectively.

There were no false aborts* in any of the Mode A abort simulations and all ejections were executed within the window defining the 100 percent safe escape probability (Figure 3-6). The results of the Mode A data analysis show the crew to be able to achieve the ejection timing requirement either with or without the EJECT light. It must be emphasized, however, that without the light the crew is

* False aborts are crew-initiated aborts when no abort-forcing failure has occurred.

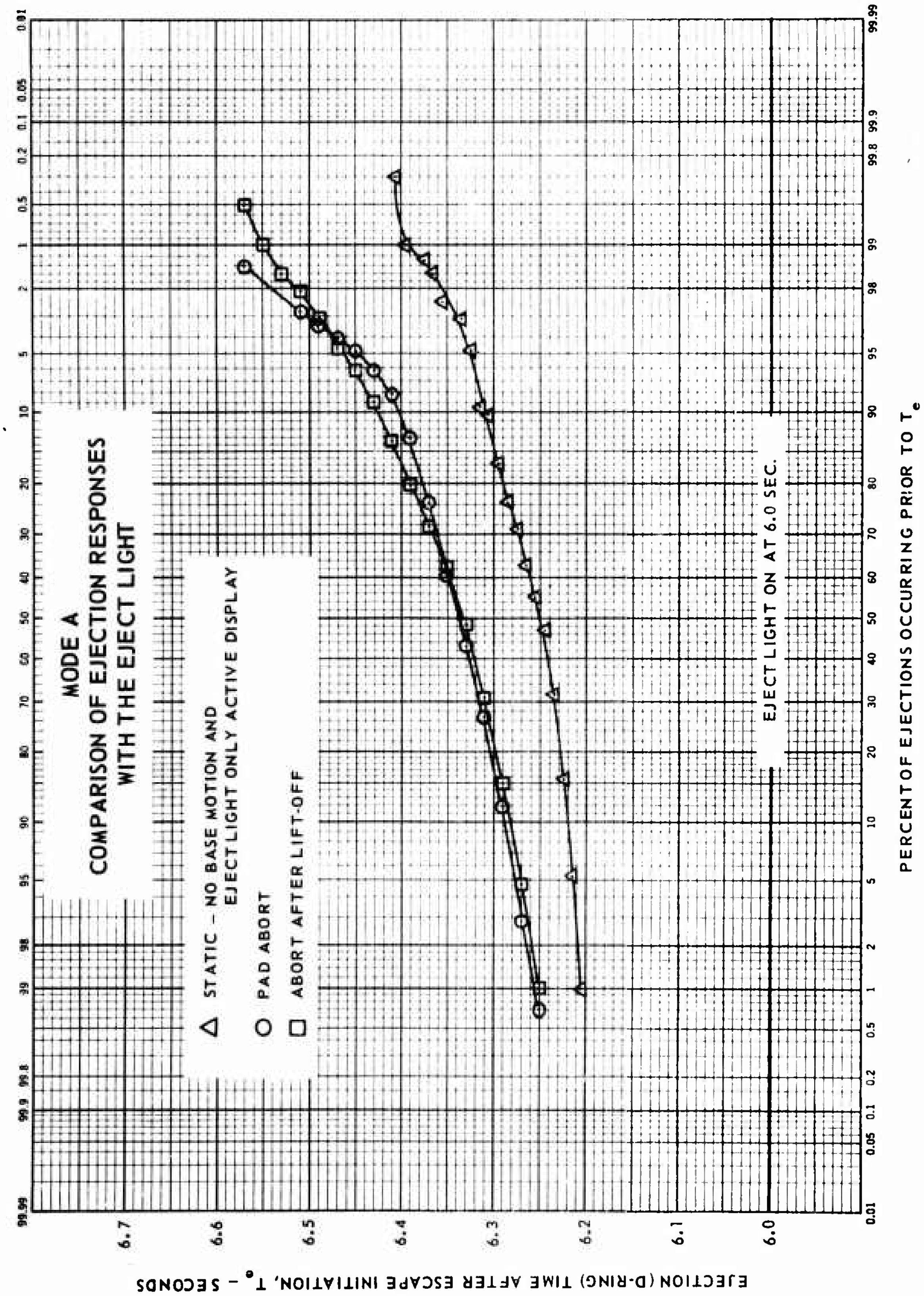

MODE A
COMPARISON OF EJECTION RESPONSES
WITH THE EJECT LIGHT
STATIC – NO BASE MOTION AND
EJECT LIGHT ONLY ACTIVE DISPLAY
PAD ABORT
ABORT AFTER LIFT-OFF
EJECT LIGHT ON AT 6.0 SEC.
PERCENT OF EJECTIONS OCCURRING PRIOR TO T_e
EJECTION (D-RING) TIME AFTER ESCAPE INITIATION, T_e – SECONDS
6.7
6.6
6.5
6.4
6.3
6.2
6.1
6.0

FIGURE 7-2

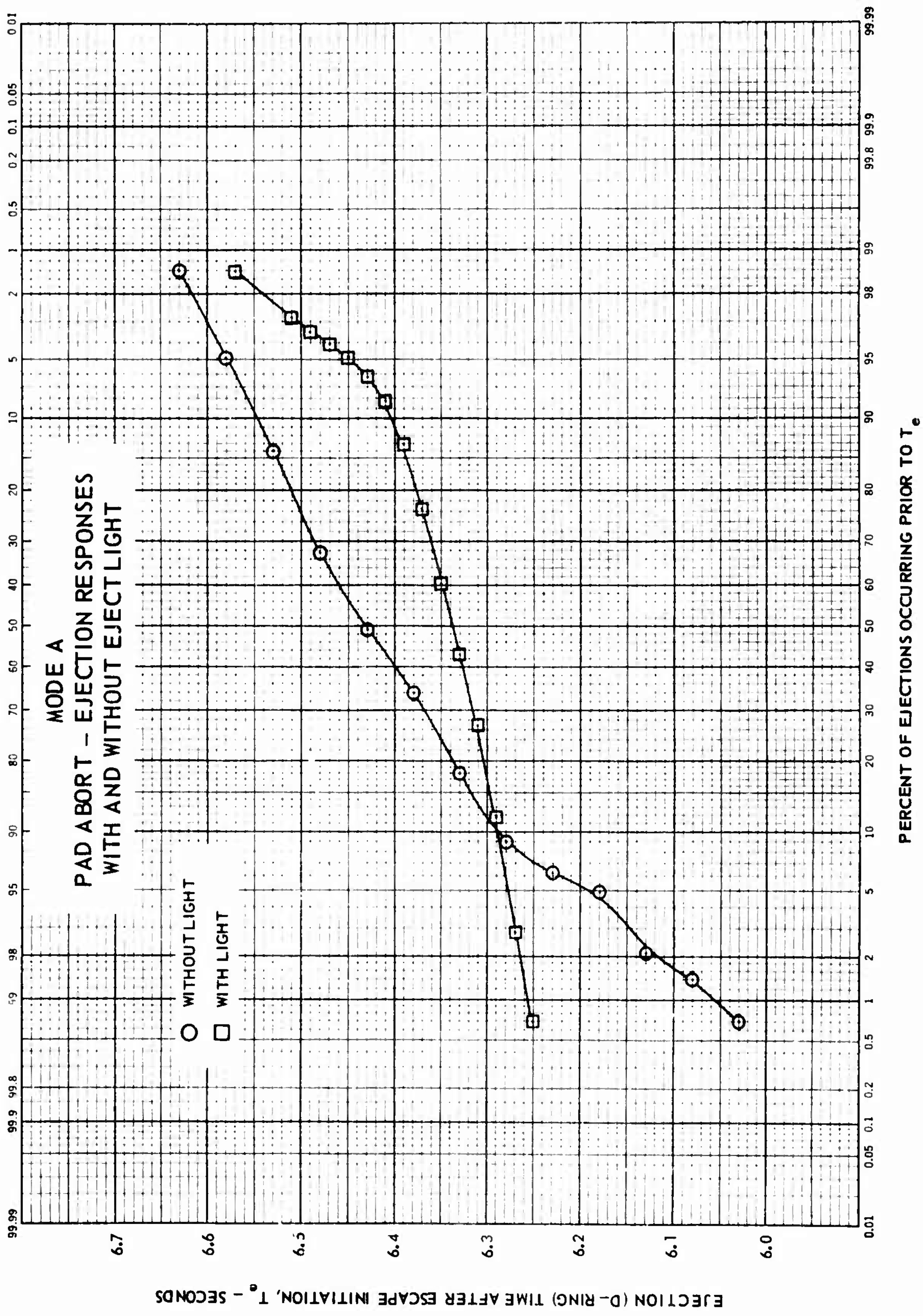

MODE A
PAD ABORT – EJECTION RESPONSES
WITH AND WITHOUT EJECT LIGHT
WITHOUT LIGHT
WITH LIGHT
PERCENT OF EJECTIONS OCCURRING PRIOR TO T_e
EJECTION (D-RING) TIME AFTER ESCAPE INITIATION, T_e – SECONDS
6.7
6.6
6.5
6.4
6.3
6.2
6.1
6.0

FIGURE 7-3

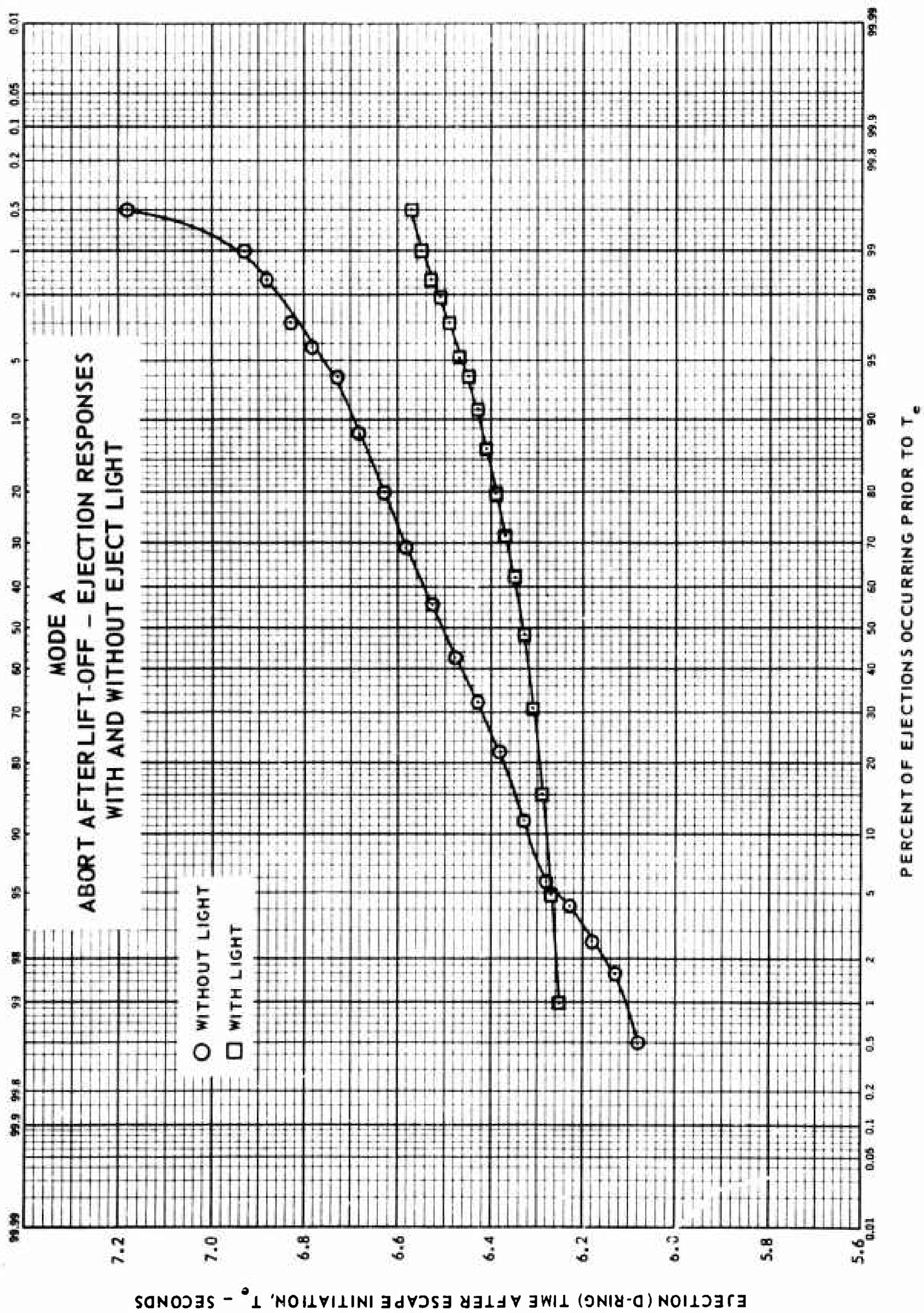

MODE A
ABORT AFTER LIFT-OFF – EJECTION RESPONSES
WITH AND WITHOUT EJECT LIGHT
WITHOUT LIGHT
WITH LIGHT
PERCENT OF EJECTIONS OCCURRING PRIOR TO T_e
EJECTION (D-RING) TIME AFTER ESCAPE INITIATION, T_e – SECONDS

FIGURE 7-4

7.1 (Continued)

apparently dependent upon being able to discriminate the retro-rocket burnout. There is no basis upon which the acceleration and particularly the noise level simulation at LTV can be firmly qualified as being representative of an actual abort situation.

7.2 Mode B Escape Initiation Timing

7.2.1 Basic Data vs Escape Action Windows - The basic individual escape initiation response data for all simulation cases are shown in Figures 7-5 through 7-10 as a function of malfunction type and thrust termination time. Also shown are the appropriate safe escape windows relative to time after the rate threshold is achieved.

Figure 7-6 shows that roll control lock-out has a significant effect on the escape action window for TVC null failures after 60 seconds of flight. However, crew comments and early observation of the data indicated that response times were not being influenced by roll control after thrust termination. The test program was composed of cases for which analytical background was available from studies based upon launch vehicle motion tapes, most of which did not include roll lock-out effects. For this reason, the bulk of the simulation was conducted without lock-out during the period when the pitch-up command at thrust termination is used (27 to 90 seconds). Since roll lock-out is presently being incorporated into the TIIIM MDS logic, it is of primary concern to ascertain whether or not the simulation response time data were influenced by this feature.

The significance of the roll lock-out effect in the escape initiation response time has been statistically evaluated using an analysis of variance technique.* The analysis is summarized below and shows that when the data measured with roll

* The Analysis of Variance is a statistical tool used to determine which variables, if any, are imposing a significant variation in the distribution of a sample of

MODE B ABORT
SAFE ESCAPE WINDOWS AND BASIC RESPONSE DATA
STRAIGHT-AHEAD MALFUNCTIONS

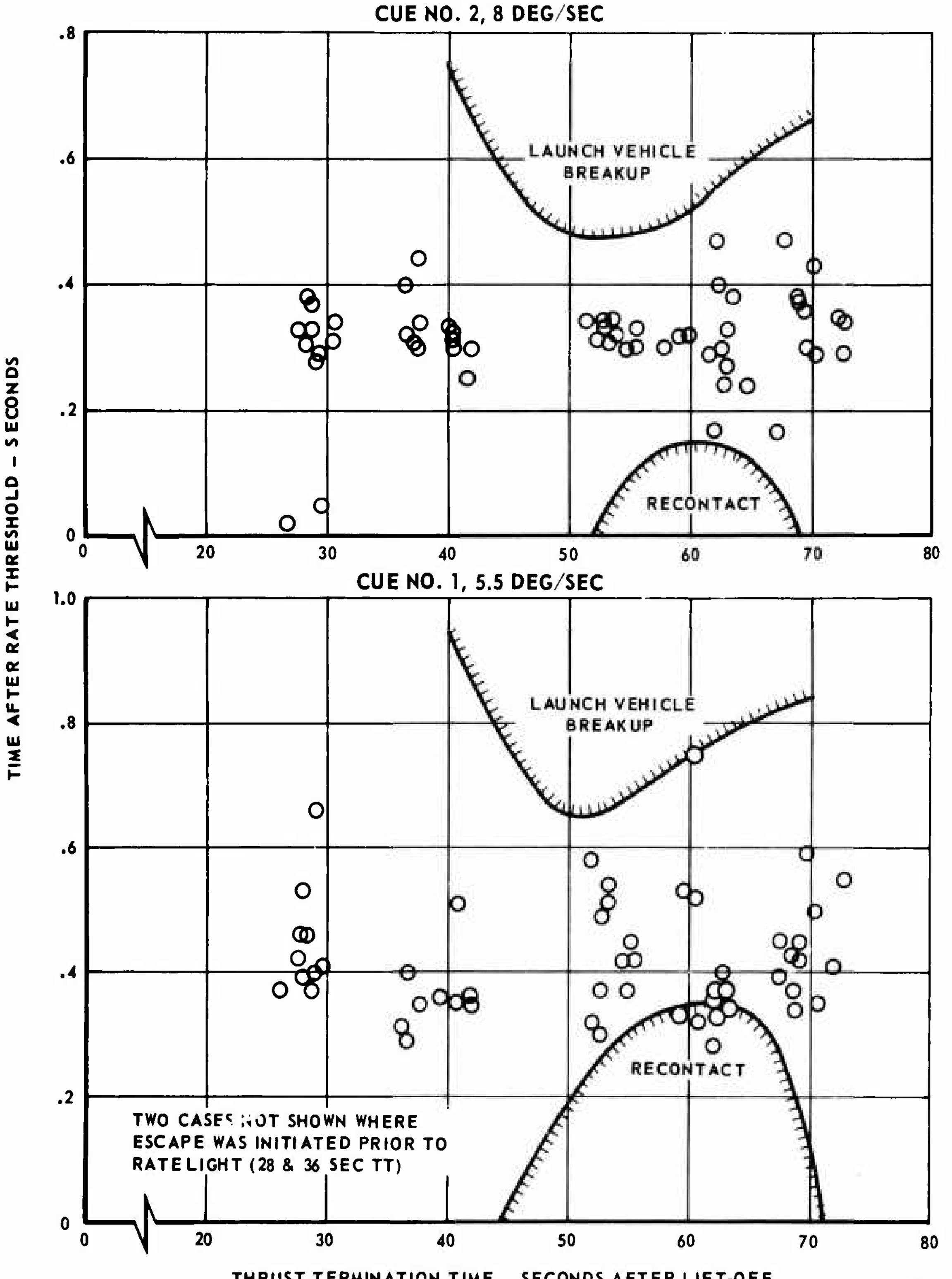


FIGURE 7-5

MODE B ABORT
SAFE ESCAPE WINDOWS AND BASIC RESPONSE DATA
TVC NULL MALFUNCTIONS

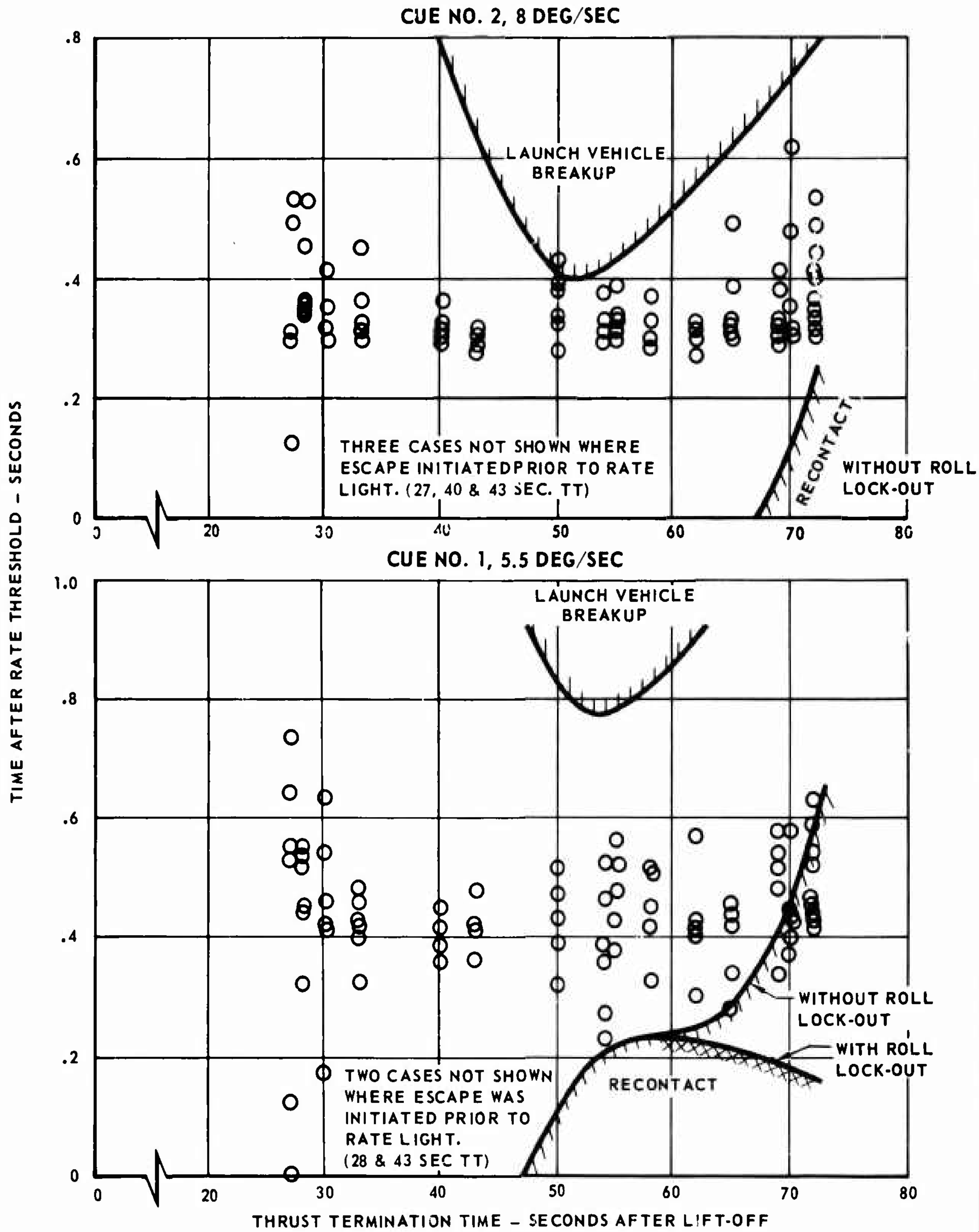


FIGURE 7-6

MODE B ABORT
SAFE ESCAPE WINDOWS AND BASIC RESPONSE DATA
BURNTHROUGH – OPPOSED MALFUNCTIONS

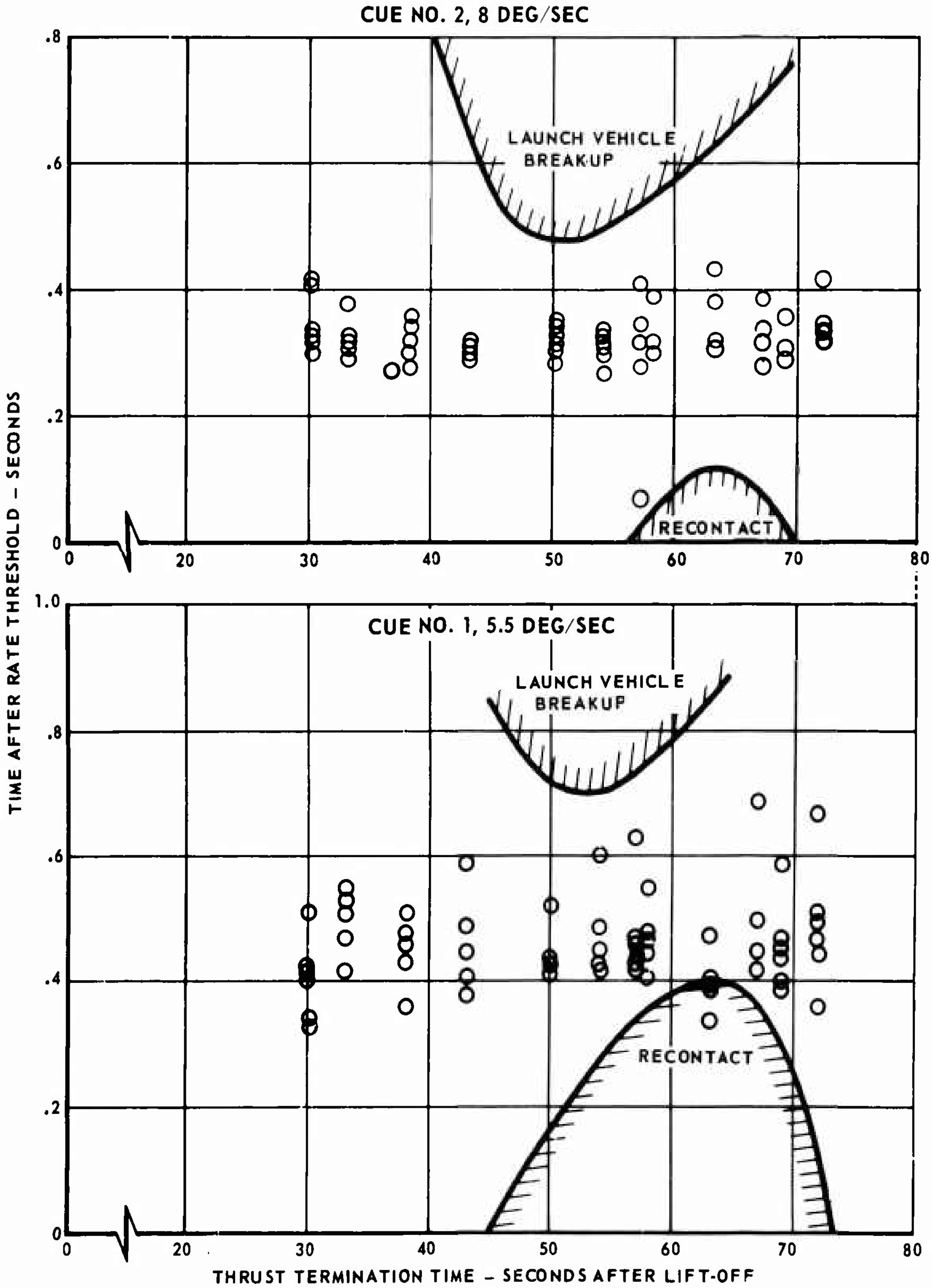


FIGURE 7–7

MODE B ABORT
SAFE ESCAPE WINDOWS AND BASIC RESPONSE DATA
SRM BURNTHROUGH (AUGMENT) MALFUNCTIONS

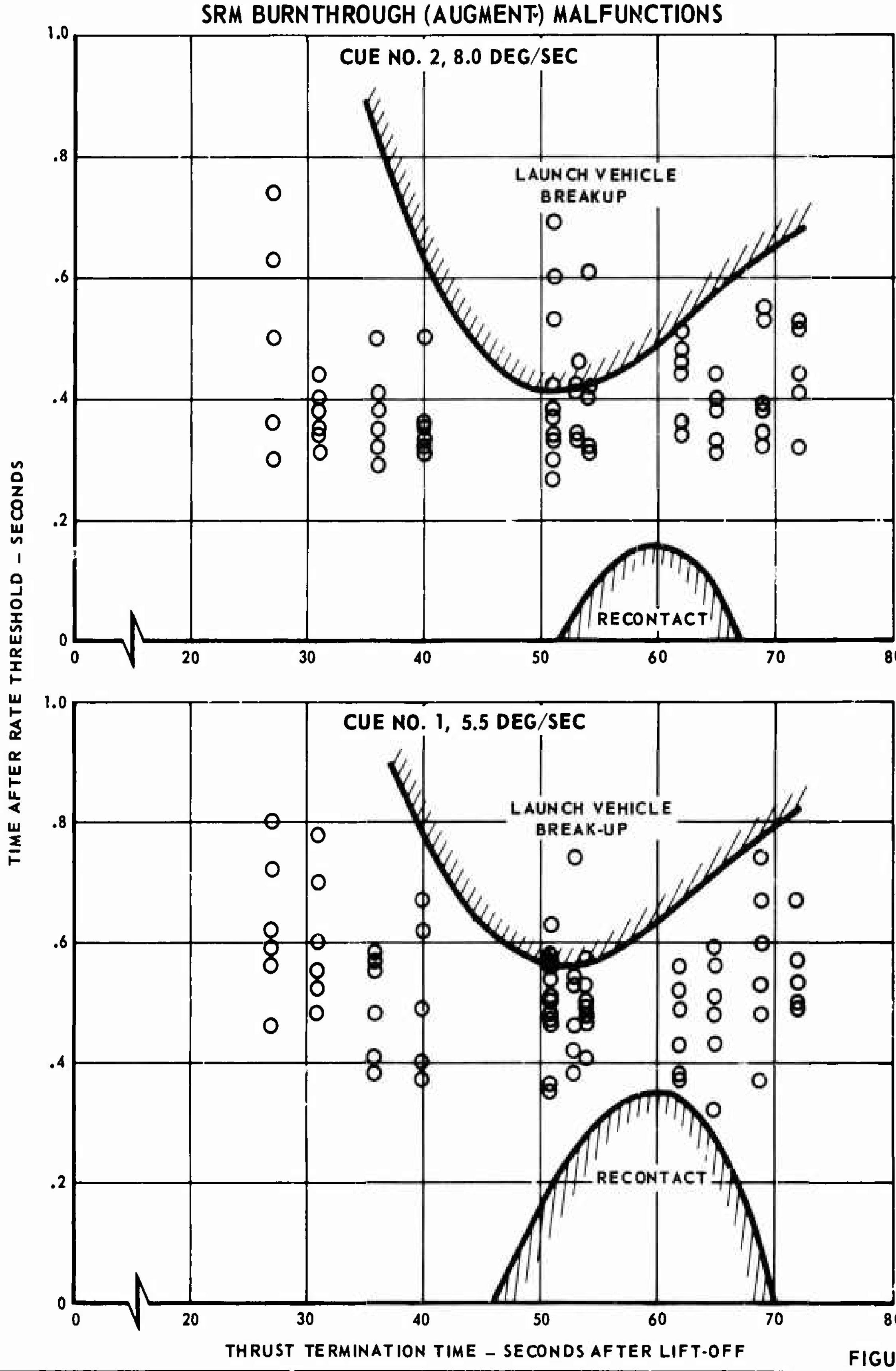


FIGURE 7-8

MODE B ABORT
SAFE ESCAPE WINDOWS AND BASIC RESPONSE DATA
8 DEG/SEC OVERRATE THRESHOLD
FDI SET FOR HIGH RATE
(CUE NO. 3)

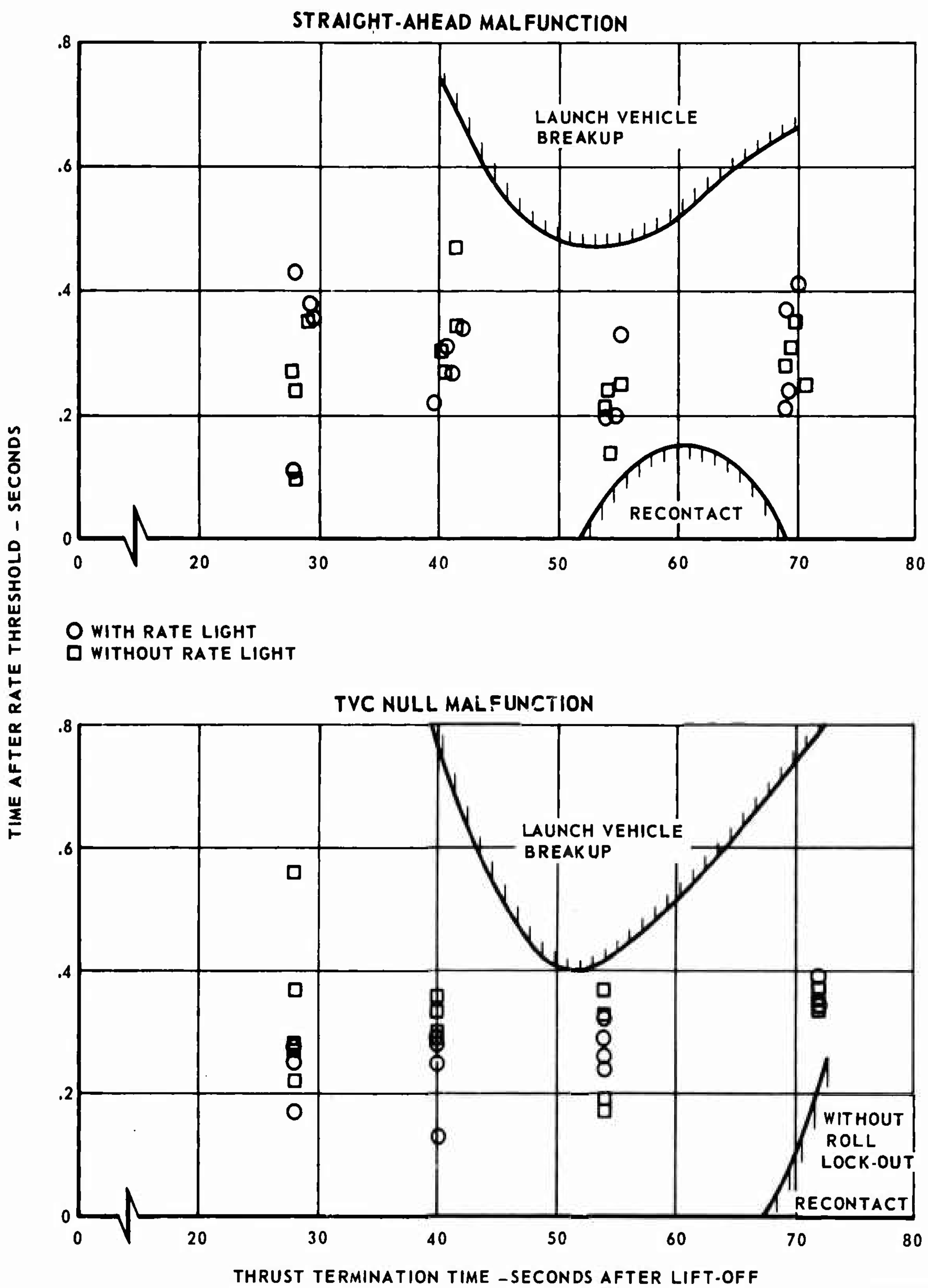


FIGURE 7-9

MODE B ABORT
SAFE ESCAPE WINDOWS AND BASIC RESPONSE DATA
8 DEG/SEC OVERRATE THRESHOLD
FDI SET FOR HIGH RATE
(CUE NO. 3)

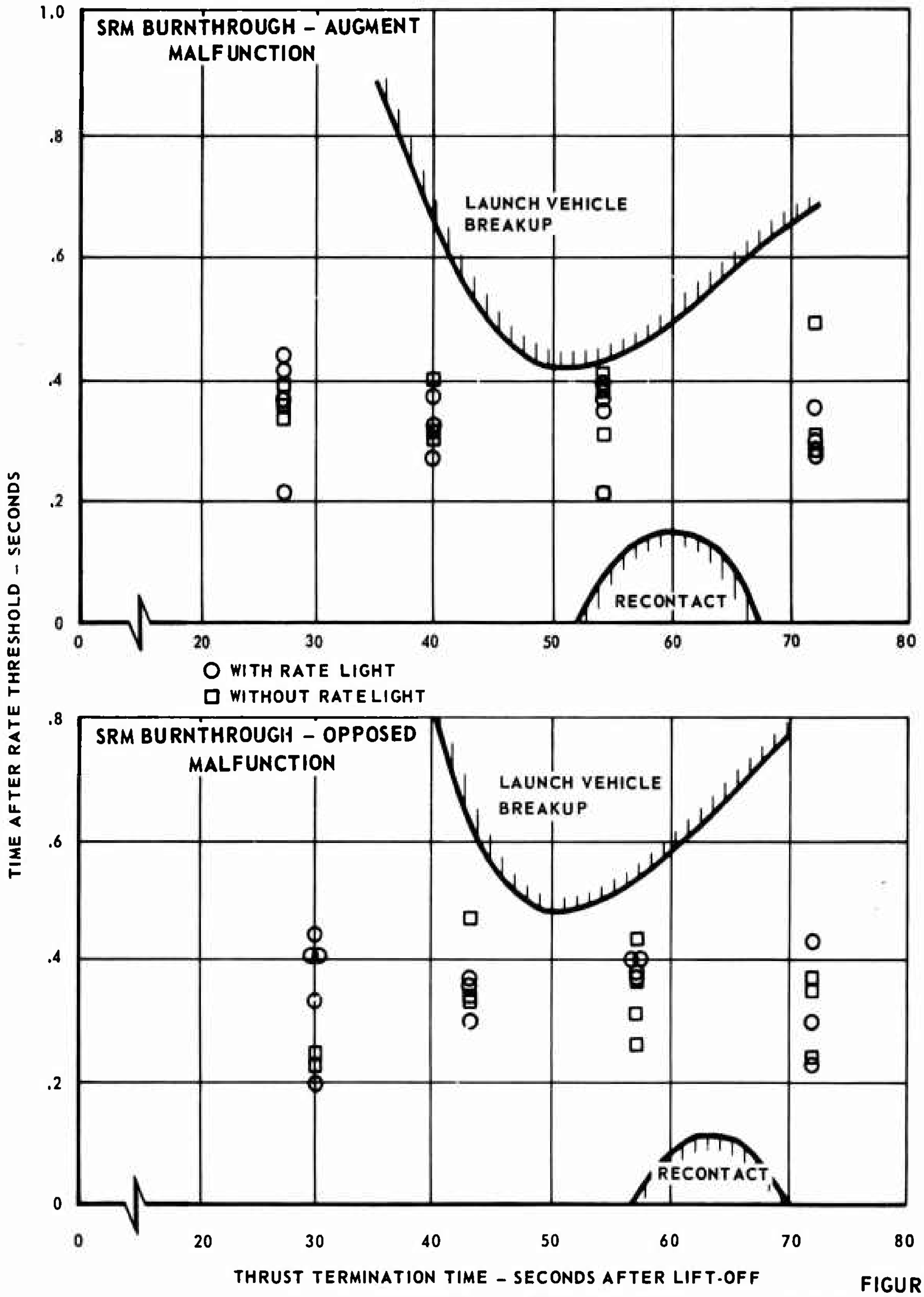


FIGURE 7-10

7.2.1 (Continued)

control locked out are pooled with data for the same cases with roll control simulated, the significant source of variation in the pooled data distribution is due only to the different malfunction types and not roll control.

ANALYSIS OF VARIANCE SUMMARY

INDEPENDENT EFFECT	COMPUTED F-RATIO	TABLE F-RATIO	SIGNIFICANCE
(a) Roll Control	1.667	3.99	No
(b) Malfunction Type	9.833	3.14	Yes
(axb) Interaction	0.500	3.14	No

With this evidence the response time data are treated without regard to the lack of roll lock-out in most of the simulation, and only the escape action windows for the roll lock-out condition are considered in subsequent discussions.

The basic data plots in Figures 7-5 through 7-10 help define a test "box score" of the successful escapes in each test segment. There were no false aborts in any of the Mode B runs, and only 10 unsafe** escapes out of 300 trials with the RATE light activated by the 5.5 degree/second rate threshold and 7 out of 300 with the RATE light activated at 8 degrees/second were recorded. No unsafe escapes were recorded in 64 trials for the secondary objective data where the FDI

---

data. Usually it is hypothesized that a pool of data containing one or more independent variables is not biased by the data associated with each of the variables or a combination of the variables. An F-ratio is computed from the data for each variable and is compared with an F-ratio taken from a statistical table. If the computed F-ratio exceeds the table F-ratio then the hypothesis, that the data pool is unbiased by that variable, must be rejected. The risk that a valid hypothesis will be rejected in this process is dependent upon the significance level chosen for entering the F-ratio table. A 5% significance level, most often used by statisticians, was adopted for the analyses in this report. The reader is directed to any statistical handbook or text for additional information.

** Unsafe escapes are defined as those that violate the launch vehicle breakup or spacecraft recontact boundaries.

7.2.1 (Continued)

unit was used with the 8 degree/second threshold. These box scores reflect, to some extent, the excellent crew performance achieved during the test, but are otherwise too dependent upon the abort time distribution in the run schedule to produce meaningful conclusions.

It is also observed that in some instances the crew apparently did not wait for the RATE light before initiating escape. None of these cases were recorded as unsafe escapes; however, they do represent violations of abort procedure. No particular cause can be assigned to these premature responses except for those in the vicinity of the Mode A/B switchover at 27 seconds. Here, it is confusing to the crewmen when an incipient failure occurs in the Mode A area but abort is not required until at or just beyond the switchover to Mode B. The premature escape attempts in early Mode B are not a serious compromise of procedure since a Mode A abort can successfully be carried out until 32 seconds after lift-off.

7.2.2 Response Time Characteristics - The analysis of escape initiation response time data will be separated at this point from the considerations of safe escape criteria. It has been shown previously that the escape action windows are flexible to a degree with respect to the rate threshold selection. It will now be shown that crew response characteristics are also flexible and will vary according to the cue given and the subsequent action required.

The minimum response performance may be inferred with the aid of static data, where the least amount of distraction was present to affect the crewman's task. Figure 7-11 summarizes the static response characteristics measured at LTV, which show that the fastest responses were never less than 220 milliseconds and that responses of less than 200 milliseconds should not occur except with very low probabilities (less than one in 10,000). It therefore seems highly probable

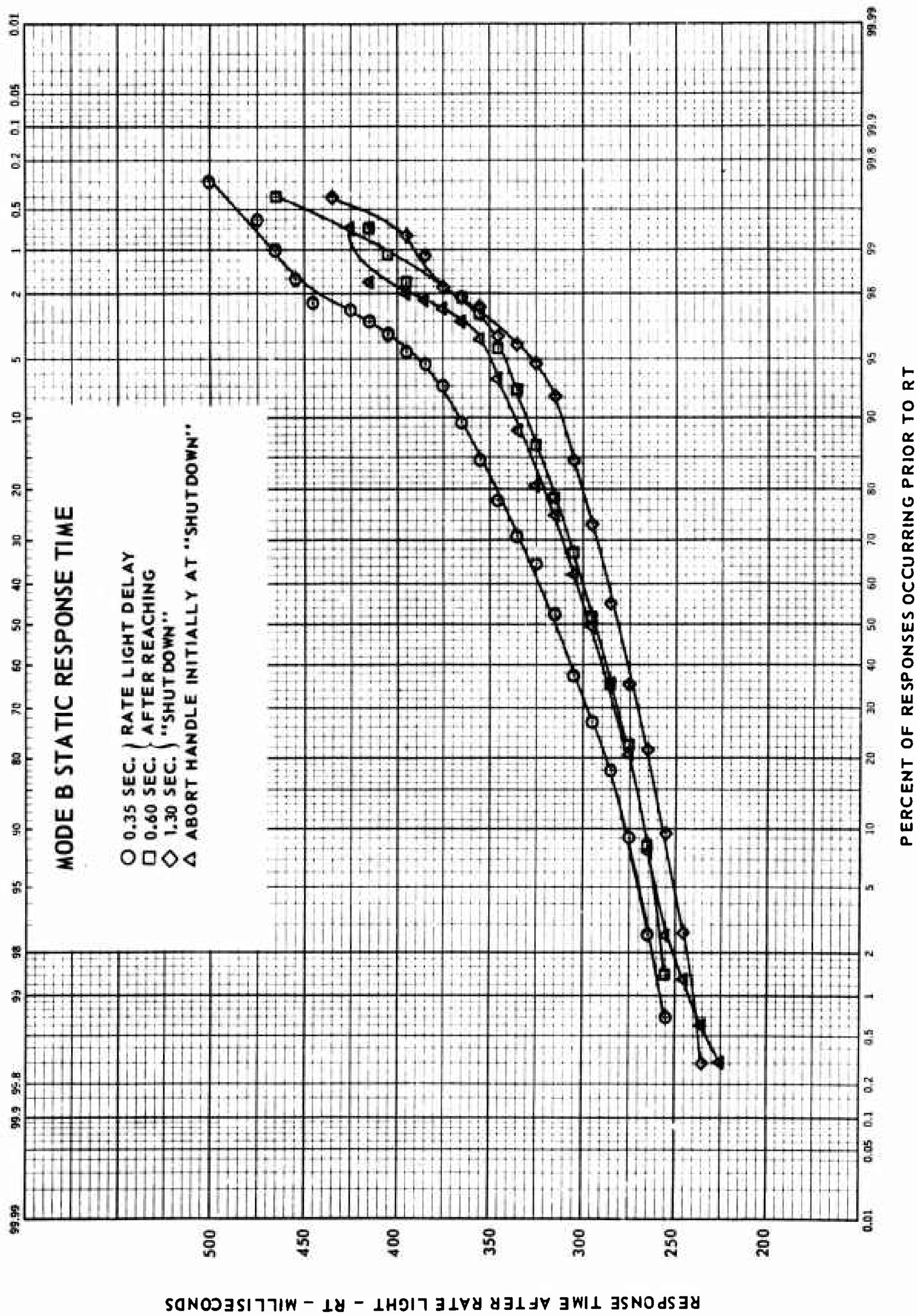

MODE B STATIC RESPONSE TIME
○ 0.35 SEC. ⎫ RATE LIGHT DELAY
□ 0.60 SEC. ⎬ AFTER REACHING
◇ 1.30 SEC. ⎭ "SHUTDOWN"
△ ABORT HANDLE INITIALLY AT "SHUTDOWN"
PERCENT OF RESPONSES OCCURRING PRIOR TO RT
RESPONSE TIME AFTER RATE LIGHT - RT - MILLISECONDS
500
450
400
350
300
250
200

FIGURE 7-11

7.2.2 (Continued)

that test responses of less than 200 milliseconds represent violations of crew procedures, where the crewman began his response prior to receiving the RATE-light cue. On this basis all data showing less than 200 milliseconds response time are culled from the data pool prior to further analysis* because, at this point, the analysis objective is limited to consideration of the response characteristics with respect to the cues being used as stimuli.

Consider next the distributions of actual escape initiation response times for the various crew actions required. The Cue 1 responses (Figure 7-12) reflect the procedure of placing the abort handle in the ABORT position as close as possible to 0.5 seconds after the RATE light. In the Cue 2 procedure (Figure 7-13) the crew were instructed to advance the handle to the ABORT position as fast as possible after the RATE light. Finally, the Cue 3 responses (Figure 7-14) show the results when the crew follow the pitch rate build-up on the FDI needles and go to the ABORT position when the threshold rate (8 degrees/second) is reached or when the RATE light comes on. Simulation of RATE light failures was included in the Cue 3 cases. It is further noted that, since the Cue 3 cases did not always provide a discrete cue, the justification for culling out early response times does not exist, and the few early responses that did occur are considered possible within these procedures.

Notable variations in response time are seen in Figures 7-12, -13, and -14, both among malfunctions and among cues. Also, Figures 7-5 through 7-10 suggest possible variation due to thrust termination time. In order to assess the

* The likelihood of the crew violating procedures is indeed a portion of the ultimate crew risk determination and is considered later in Section 8.

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MODEL 195B

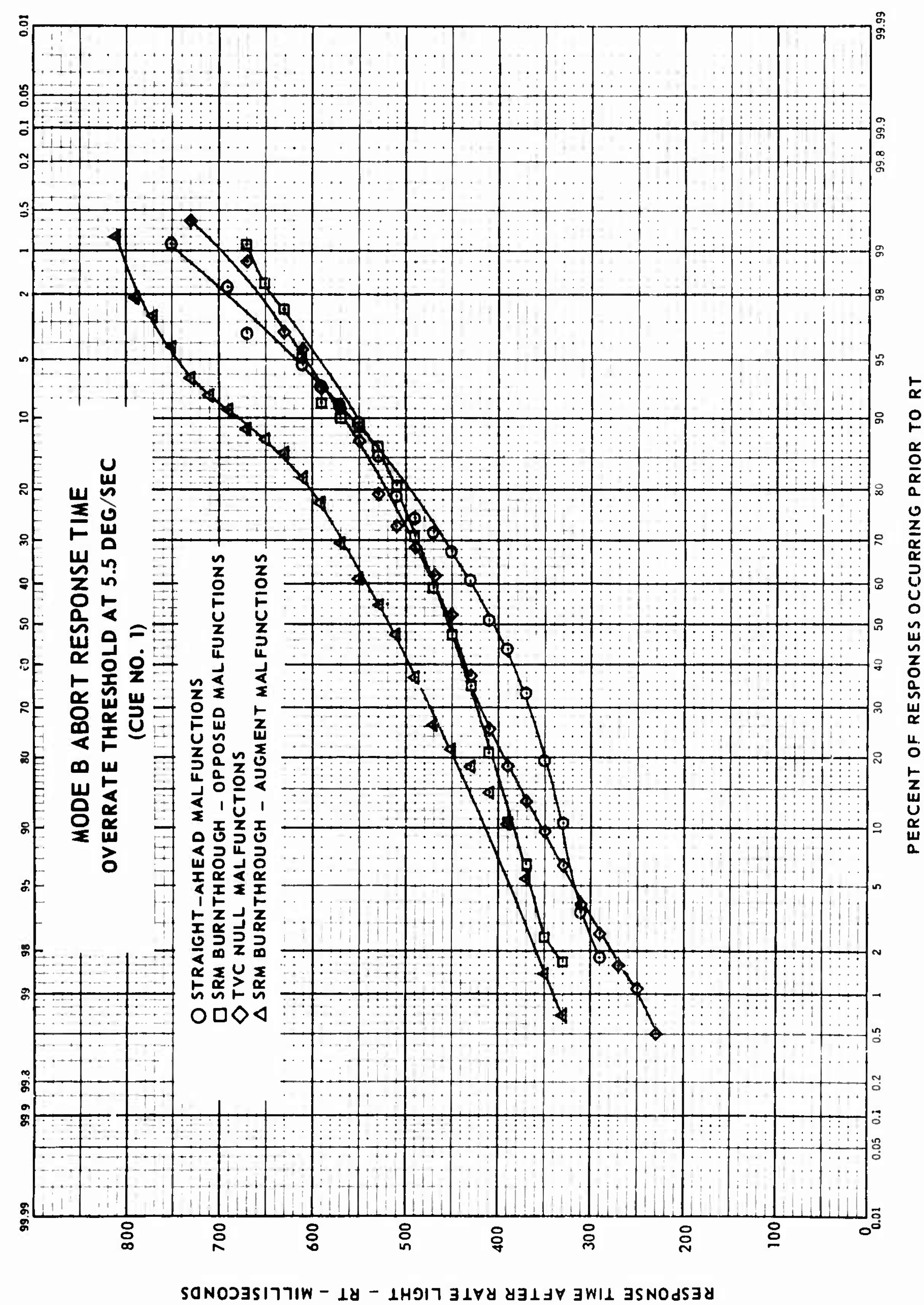

FIGURE 7-12

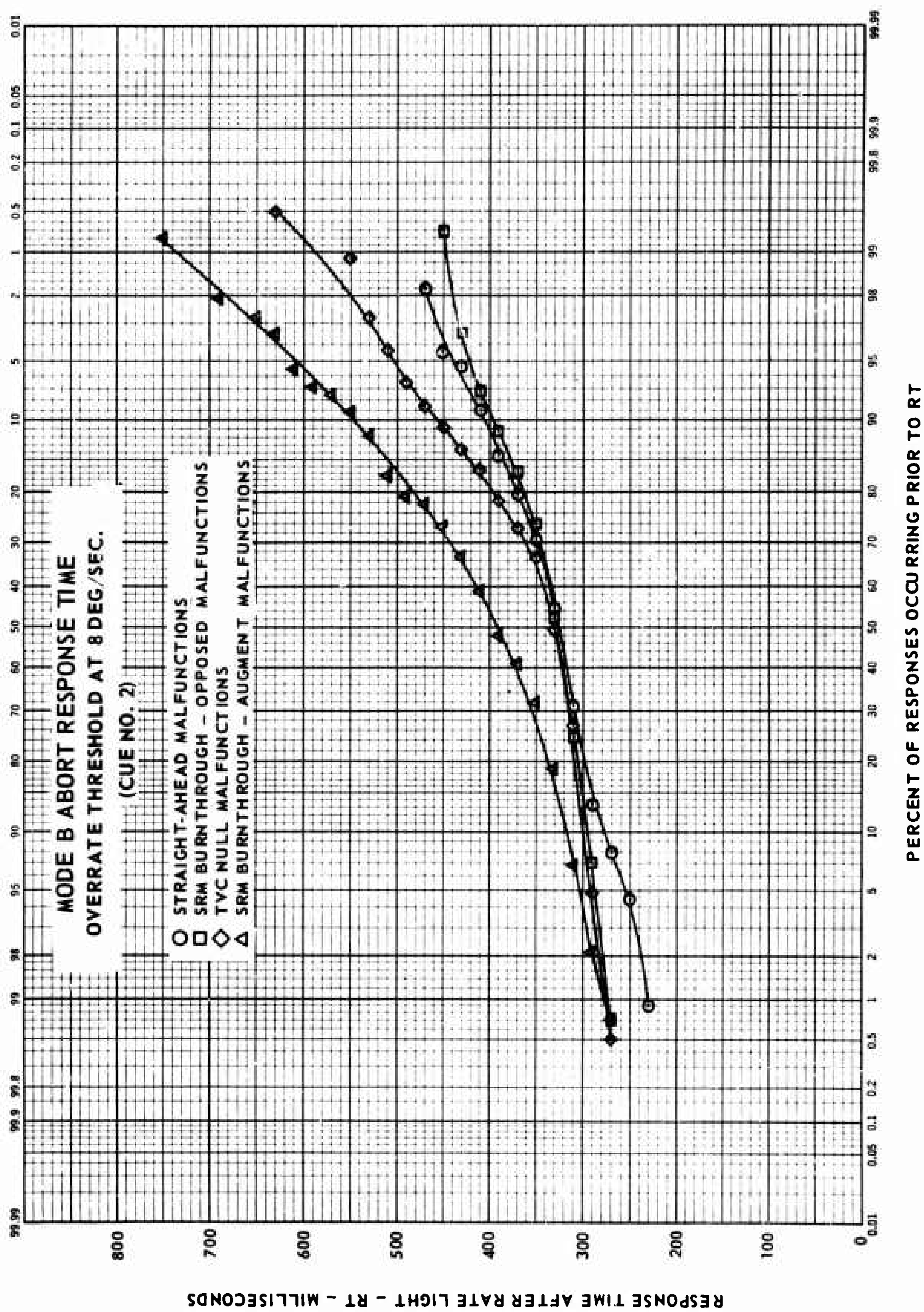
MODE B ABORT RESPONSE TIME
OVERRATE THRESHOLD AT 8 DEG/SEC.
(CUE NO. 2)
○ STRAIGHT-AHEAD MALFUNCTIONS
□ SRM BURNTHROUGH - OPPOSED MALFUNCTIONS
◇ TVC NULL MALFUNCTIONS
△ SRM BURNTHROUGH - AUGMENT MALFUNCTIONS
PERCENT OF RESPONSES OCCURRING PRIOR TO RT
RESPONSE TIME AFTER RATE LIGHT - RT - MILLISECONDS

FIGURE 7-13

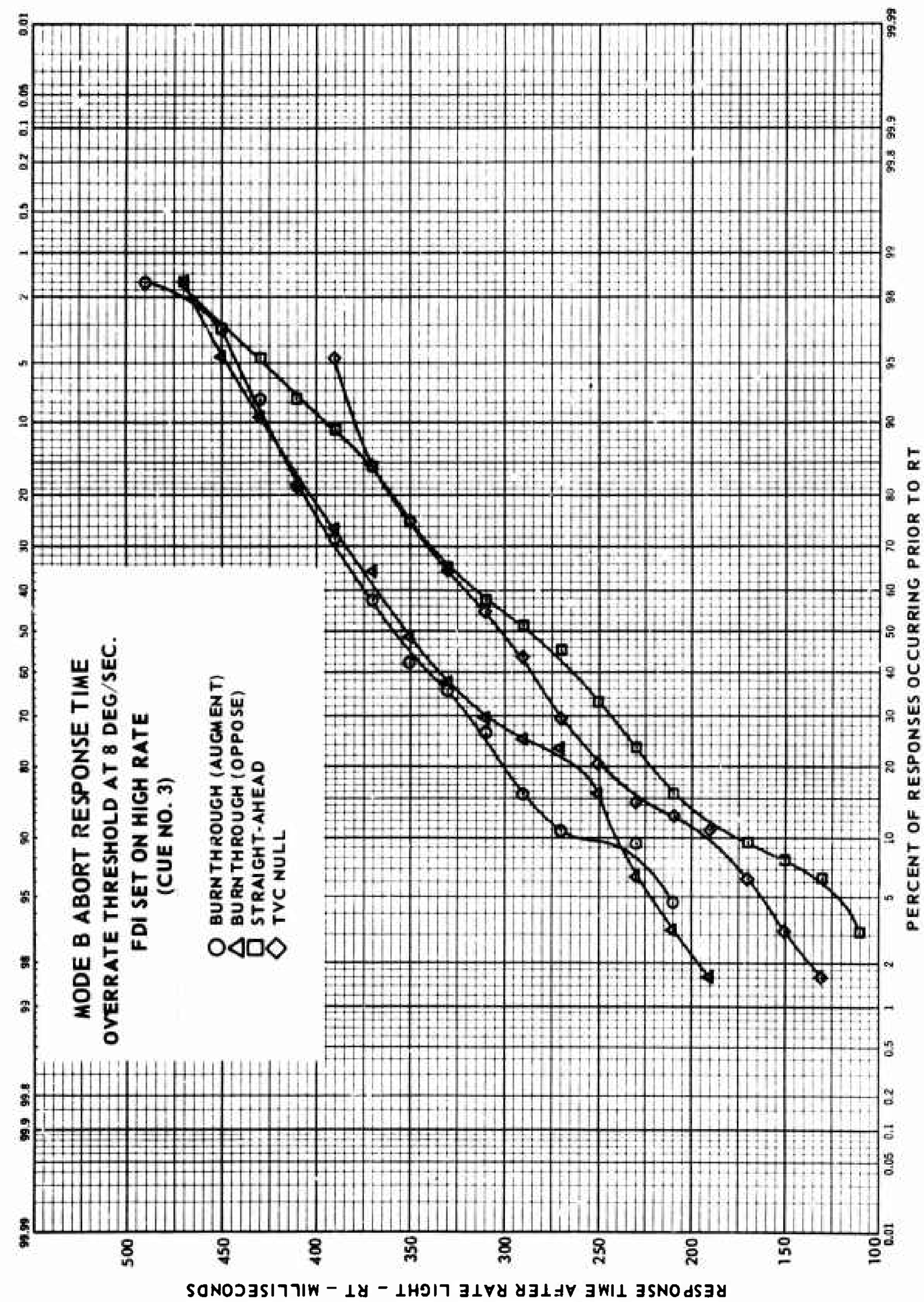
MODE B ABORT RESPONSE TIME
OVERRATE THRESHOLD AT 8 DEG/SEC.
FDI SET ON HIGH RATE
(CUE NO. 3)
○ BURNTHROUGH (AUGMENT)
△ BURNTHROUGH (OPPOSE)
□ STRAIGHT-AHEAD
◇ TVC NULL
500
450
400
350
300
250
200
150
100
RESPONSE TIME AFTER RATE LIGHT - RT - MILLISECONDS
PERCENT OF RESPONSES OCCURRING PRIOR TO RT

FIGURE 7-14

7.2.2 (Continued)

significance of these possible effects, an analysis of variance was performed on the data for each cue, considering malfunction type and thrust termination time as independent effects. For Cue 3 the cases with and without the RATE light constitute an additional effect.

In the initial analysis for Cue 1 both malfunction type and TT time are found to be significant. Figure 7-12 suggests that responses to SRM burnthrough-augment malfunctions are unique. By repeating the analysis of variance with these data deleted, the remaining pool of data is shown to be free of all significant effects. Similar analyses of the Cue 2 data lead to the same results, thus it is concluded that the response characteristics for Cue 1 and Cue 2 are statistically free from effects due to TT time and all malfunction types except SRM burnthrough-augment.

ANALYSIS OF VARIANCE SUMMARY

CUE NO. 1 ALL RESPONSE DATA POOLED

INDEPENDENT EFFECT	COMPUTED F-RATIO	TABLE F-RATIO	SIGNIFICANCE
(a) TT Time	4.333	2.41	Yes
(b) Malfunction Type	15.628	2.65	Yes
(axb) Interaction	1.654	1.80	No

CUE NO. 1 ALL DATA POOLED EXCEPT SRM BURNTHROUGH-AUGMENT

INDEPENDENT EFFECT	COMPUTED F-RATIO	TABLE F-RATIO	SIGNIFICANCE
(a) TT Time	2.085	2.42	No
(b) Malfunction Type	2.563	3.05	No
(axb) Interaction	1.408	1.99	No

7.2.2 (Continued)

The TT time significance is eliminated, along with the malfunction significance, when the burnthrough-augment data are deleted from the pool of all Cue 1 data. The implication that the TT effect remains within the burnthrough-augment pool requires reexamination of the response data. An analysis of variance due to TT time effect shows a definite significance. It was noted that during five runs the crew failed to achieve the SHUTDOWN position until more than 700 milliseconds after the ABORT light and all of these occurred in the earliest Mode B time interval (27 to 33 seconds after lift-off implying confusion due to A/B switchover). When these late shutdown data are deleted the significance is removed.

ANALYSIS OF VARIANCE SUMMARY

CUE NO. 1 SRM BURNTHROUGH-AUGMENT DATA (ONLY)

INDEPENDENT EFFECT	COMPUTED F-RATIO	TABLE F-RATIO	SIGNIFICANCE
All TT Time Data	3.927	2.54	Yes
Without Late Shutdowns	1.860	2.56	No

The Cue 2 data do not show a statistically significant TT time effect; however, examination of the data revealed two exceptionally late shutdown times (.95 and 1.05 seconds) and both were in the early Mode B time interval. For the longer of these, a comment on the on-site data tab sheet notes the crewman reported confusion over which abort mode he was in. It appears that in both Cue 1 and 2 data manifestation of the confusion at Mode A/B switchover has been found, and that these data points must be culled to exclude procedure violations from influencing the models of crew performance.

A

7.2.2 (Continued)

ANALYSIS OF VARIANCE SUMMARY

CUE NO. 2 ALL RESPONSE DATA POOLED

INDEPENDENT EFFECT	COMPUTED F-RATIO	TABLE F-RATIO	SIGNIFICANCE
(a) TT Time	1.630	2.41	No
(b) Malfunction Type	17.556	2.65	Yes
(axb) Interaction	0.704	1.80	No

CUE NO. 2 ALL DATA POOLED EXCEPT SRM BURNTHROUGH-AUGMENT

INDEPENDENT EFFECT	COMPUTED F-RATIO	TABLE F-RATIO	SIGNIFICANCE
(a) TT Time	0.927	2.42	No
(b) Malfunction Type	1.805	3.05	No
(axb) Interaction	0.854	1.99	No

When the Cue 3 response data are submitted to the same statistical tests a somewhat different result than that seen with Cues 1 and 2 occurs. First, the analysis of variance shows that the pool of all response data are not significantly affected by whether or not the RATE light is illuminated at the rate threshold. This was also indicated by crew comments to the effect that when they concentrate on the FDI needles they are unable to consciously notice the RATE light come on. Second, malfunction type produces a significance in the pool of all Cue 3 data, but unlike Cues 1 and 2, both SRM burnthrough malfunctions are generating the effect. Subsequent analysis shows that the two burnthrough cases may be combined to give a pool that is without significant effects, and the straight-ahead and TVC null data can also be combined into another pool that is free of significant effects.

7.2.2 (Continued)

ANALYSIS OF VARIANCE SUMMARY

CUE NO. 3 ALL RESPONSE DATA POOLED

INDEPENDENT EFFECT	COMPUTED F-RATIO	TABLE F-RATIO	SIGNIFICANCE
(a) TT Time	1.714	3.86	No
(b) Malfunction Type	8.857	3.86	Yes
(c) RATE Light On/Off	0.143	5.12	No
(axb) Interaction	2.786	3.18	No
(axc) Interaction	3.071	3.86	No
(bxc) Interaction	2.214	3.86	No

CUE NO. 3 SRM BURNTHROUGH DATA POOLED (AUGMENT & OPPOSED)

INDEPENDENT EFFECT	COMPUTED F-RATIO	TABLE F-RATIO	SIGNIFICANCE
(a) TT Time	0.425	9.28	No
(b) Malfunction Type	0.567	10.13	No
(axb) Interaction	2.692	9.28	No

CUE NO. 3 STRAIGHT-AHEAD AND TVC NULL DATA POOLED

INDEPENDENT EFFECT	COMPUTED F-RATIO	TABLE F-RATIO	SIGNIFICANCE
(a) TT Time	5.701	9.28	No
(b) Malfunction Type	0.504	10.13	No
(axb) Interaction	2.417	9.28	No

The results of these analyses of variance establish the groundrules for pooling the escape initiation response data to yield the response characteristics shown in Figures 7-15, -16, and -17 for Cues 1, 2, and 3, respectively. These response characteristics in turn, become the definition of crew capability for the specific crew procedures, malfunction types, and cues tested at LTV. Comparison of these

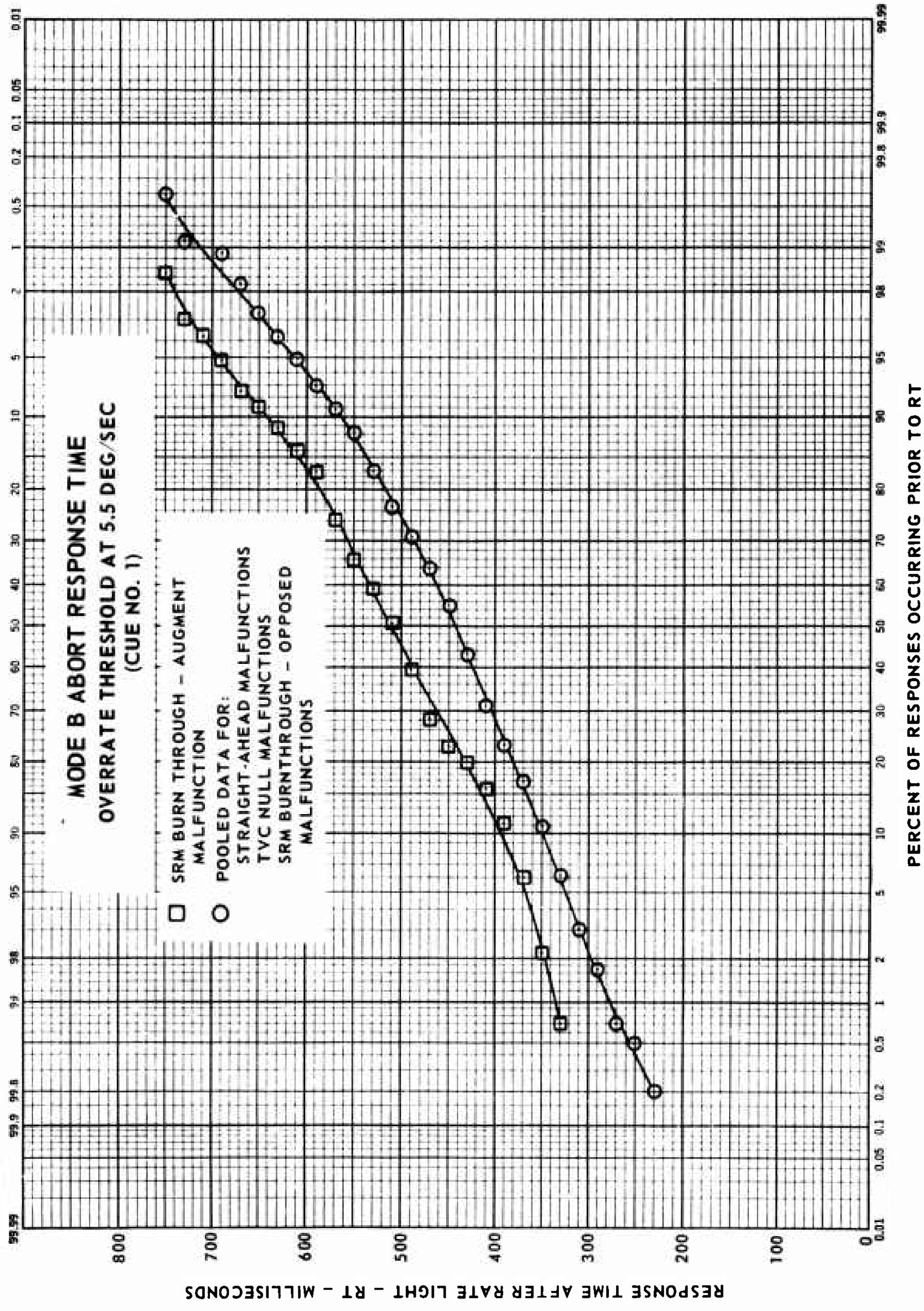
MODE B ABORT RESPONSE TIME
OVERRATE THRESHOLD AT 5.5 DEG/SEC
(CUE NO. 1)
SRM BURN THROUGH – AUGMENT MALFUNCTION
POOLED DATA FOR:
STRAIGHT-AHEAD MALFUNCTIONS
TVC NULL MALFUNCTIONS
SRM BURNTHROUGH – OPPOSED MALFUNCTIONS
PERCENT OF RESPONSES OCCURRING PRIOR TO RT
RESPONSE TIME AFTER RATE LIGHT – RT – MILLISECONDS
800
700
600
500
400
300
200
100
0

FIGURE 7–15

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MODEL 195B

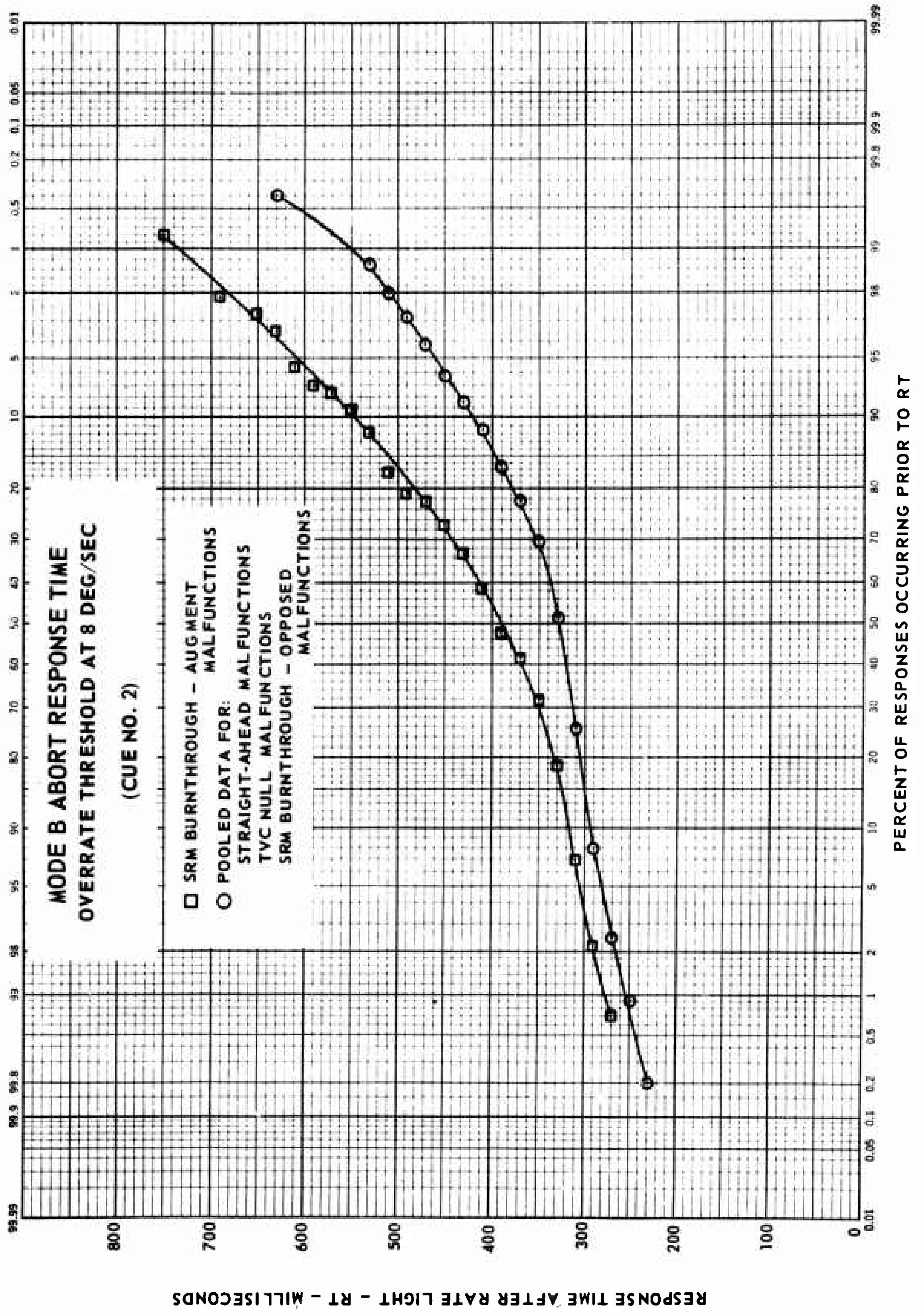

FIGURE 7–16

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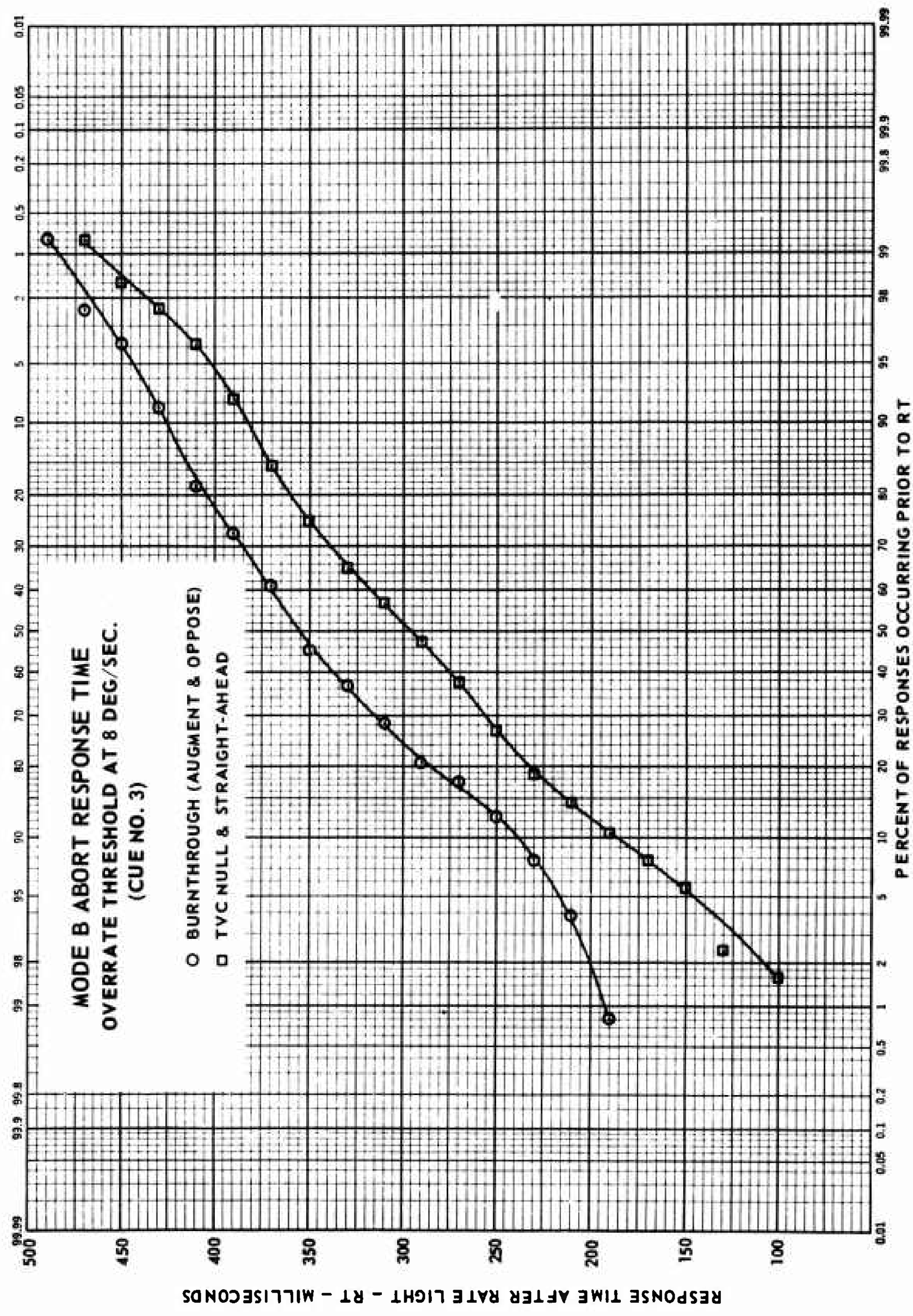

MODE B ABORT RESPONSE TIME
OVERRATE THRESHOLD AT 8 DEG/SEC.
(CUE NO. 3)
O BURNTHROUGH (AUGMENT & OPPOSE)
□ TVC NULL & STRAIGHT-AHEAD
PERCENT OF RESPONSES OCCURRING PRIOR TO RT
RESPONSE TIME AFTER RATE LIGHT - RT - MILLISECONDS
500
450
400
350
300
250
200
150
100

FIGURE 7-17

7.2.2 (Continued)

three figures shows the net effect of influences caused by these cues and procedures.

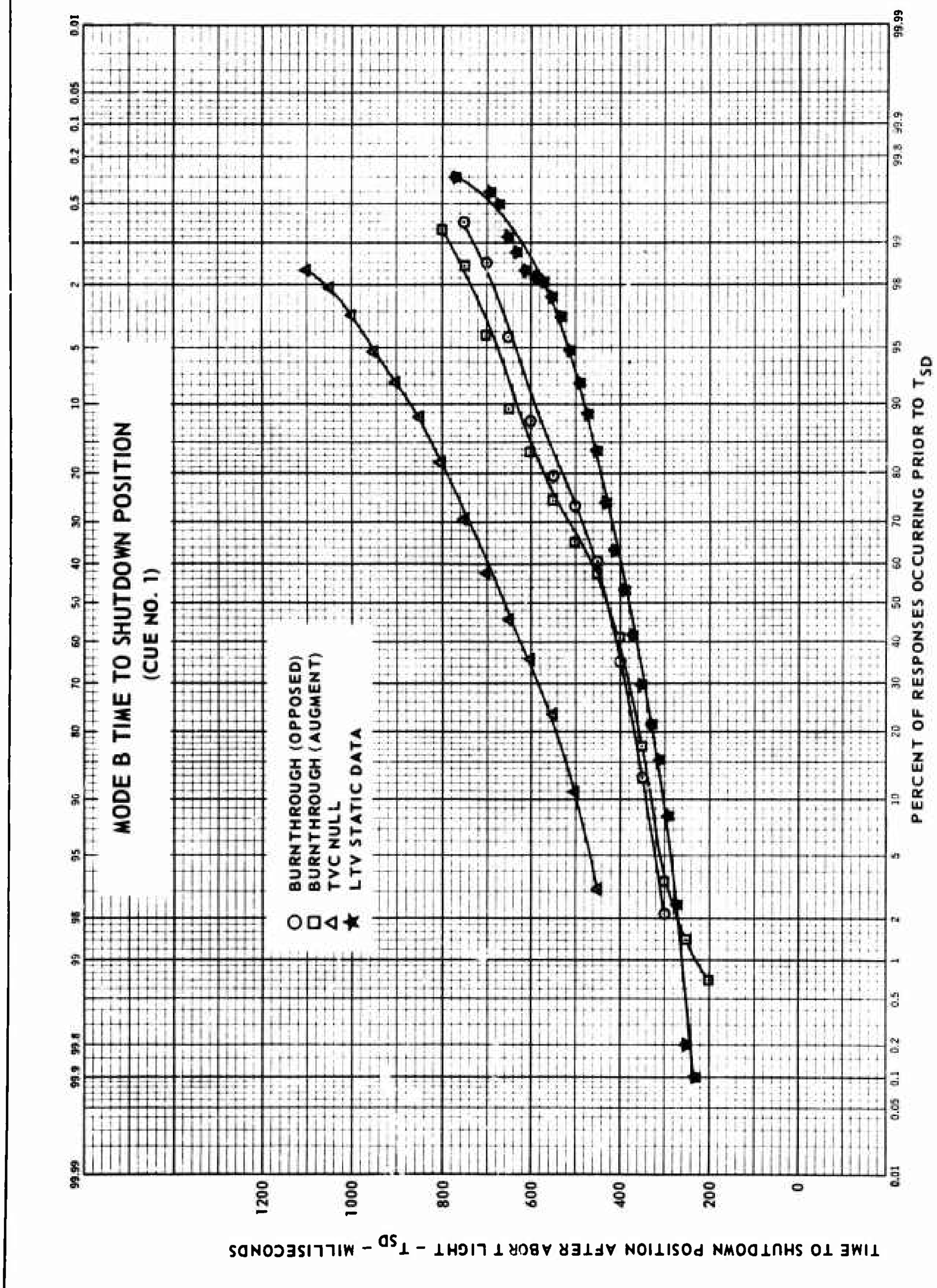
With the Cue 1 procedure the median response time for the burnthrough-augment malfunction is very nearly the desired 0.5 seconds after the RATE light, while the median response following all other malfunctions, 0.44 seconds, leads the target time by only 60 milliseconds. Also, the response data have a nearly normal distribution about the median indicating an equal likelihood that the crew will misjudge the timing in either direction.

For the Cue 2 procedure, the extreme values of response times are not altered a great deal from the Cue 1 values, but the median response time is decreased by over 100 milliseconds, giving the skewed distribution that was anticipated. Ninety percent of all responses occur in a 350 millisecond interval between 0.20 and 0.55 seconds after the RATE light, whereas with Cue 1, an interval of 480 milliseconds is required in order to accommodate 90 percent of the responses.

The result expected for the Cue 3 procedure with regard to response characteristics was not entirely clear before the test. Only a small sample of data was measured with the intention of evaluating FDI usage. Furthermore, an ideal configuration of the FDI unit was not employed (e.g., the index was a crude mark on the cover glass that introduces parallax and resolution variances). The responses show a generally normal distribution as would be expected; the median responses are between 0.30 and 0.35 seconds after the RATE light, and the full range of response measurements falls within a 400 millisecond interval, which is smaller than for any other cue tested.

7.2.2 (Continued)

The analyses of variance have produced evidence that crew escape initiation timing is dependent upon malfunction type. Hence, there must be differences in the development and timing of the escape action cues among the four malfunction types that result in varying responses from the crew. The sequence of abort events begins with failure detection and the first crew action is to place the abort handle in the SHUTDOWN position as fast as possible. This is a simple response situation. The crew may or may not anticipate the abort by detecting the failure onset in their displays, and they react either in response to the ABORT light (indicating auto TT) or in response to their own determination of the abort requirement. The launch vehicle programmed pitch commences when thrust termination occurs. For straight-ahead (non-divergent) malfunctions, TT is manually performed and therefore the abort handle is in SHUTDOWN before the critical period following TT starts. For divergent malfunctions TT was automatic in the simulation and the time to reach the SHUTDOWN position becomes important since it consumes a portion of the time available to complete the abort sequence. Figure 7-18 shows the shutdown response time distributions for the divergent malfunctions and includes, for comparison, the static responses recorded at LTV. The distributions are shown for the Cue 1 data but, because the shutdown response procedure is the same, the distributions are essentially indistinguishable among cues. Two notable features are seen in this figure; first, SHUTDOWN is accomplished with little difference between the two SRM burnthrough malfunctions, with a median response time that is only 40 milliseconds greater than the static responses; and second, TVC null malfunctions require over 200 milliseconds more time to achieve SHUTDOWN than do the burnthrough cases. The crew are able to detect the onset of the burnthrough condition in the SRM chamber pressure meter,



MODE B TIME TO SHUTDOWN POSITION
(CUE NO. 1)
BURNTHROUGH (OPPOSED)
BURNTHROUGH (AUGMENT)
TVC NULL
LTV STATIC DATA
PERCENT OF RESPONSES OCCURRING PRIOR TO T_{SD}
TIME TO SHUTDOWN POSITION AFTER ABORT LIGHT – T_{SD} – MILLISECONDS
1200
1000
800
600
400
200
0

FIGURE 7-18

7.2.2 (Continued)

and often with a roll rate output on the FDI, so that they are able to anticipate the ABORT light coming on. Thus the situation approaches the simplicity of the static tests because the decision time after the ABORT light is minimized. It also follows that achievement of the SHUTDOWN position for the TVC null cases is delayed by lack of anticipation prior to the ABORT light. In fact, only 50 milliseconds elapse in the TVC null simulation between start of the failure and auto TT. This simulation is not actually typical of TVC null malfunctions in general, but rather the specific case where a nozzle failure has destroyed the TVC ports. The nozzle failure is what the MDS detects to cause thrust termination almost simultaneously with the failure occurrence.

With the shutdown response time characteristics established, it is now possible to assess the significance by referring to Figures 3-3 and 3-4. The escape action window for the TVC null is located between 1.43 and 1.93 seconds after thrust termination. Since the shutdown response time has very low probability of exceeding 1.2 seconds after the ABORT light (TT time), the range of time for escape initiation is at least 0.23 to 0.73 seconds after achievement of the SHUTDOWN position. A similar examination for the burnthrough-opposed malfunction indicates a range of time for escape initiation of at least 0.30 to 0.77 seconds after shutdown. In both of these cases there is a positive increment of time between achievement of the SHUTDOWN position and the time when escape must be initiated. Such is not the case for the burnthrough-augment malfunctions where, because of the very rapid divergence, the escape window lies between 0.68 and 0.97 seconds after thrust termination. Figure 7-18 shows that five percent of the shutdown responses will occur after 0.68 seconds thus using part of the already narrow window. It appears that there will always be some probability

7.2.2 (Continued)

(albeit small) that SHUTDOWN will be achieved too late to then initiate escape prior to launch vehicle breakup. Furthermore, the situation cannot be improved by changing procedures or cues since the problem is intrinsic with the divergence rate build-up and the limits on abort handle travel time. In other words, since the crewman must complete his escape initiation response between 0.68 and 0.97 seconds, the RATE light cue should be given before 0.68 seconds; however, if his arrival at the SHUTDOWN position is late, the response to the RATE light is preempted and escape initiation may be late. This, then, is the circumstance that causes the crew escape initiation response characteristics to be unique following a burnthrough-augment malfunction. There has been no suitable hypothesis advanced to explain why the burnthrough-opposed cases produce characteristics similar to the augment cases using Cue 3.

8. EVALUATION AND APPLICATION OF TEST RESULTS

Before evaluating and applying the results of this test program, several points of importance are suggested for consideration.

A. Safe escape windows are entirely dependent upon spacecraft and launch vehicle performance and are subject to change as new information and analyses are available. All Stage "0" abort analyses are presently in the process of complete revision and update.

B. The cue timing used during the test was preselected without benefit of the now-available crew response characteristics. Evaluation of the escape procedures, as performed during the test, should therefore be limited to showing the relative effects of the task that the crew is required to perform for each procedure. Safe escape probabilities have little significance until an optimization of cue timing is accomplished.

C. The crew response characteristics are a much needed engineering tool for the design of escape procedures, and those measured in this test program are considered excellent for that purpose. The fact remains, however, that these results are the product of a simulation and not the actual abort situation. While every effort was expended to provide the atmosphere and environment that affect crew responses, there are shortcomings that cannot be assessed quantitatively. For this reason, crew opinion is considered a real part of the test data. Although impossible to describe with formulae or graphs, their opinion must be considered before final decisions on procedural or equipment changes are made.

In comparing the LTV abort simulation to an actual situation there are several important differences that invite discussion. Table 8-1 lists some of the more obvious factors as they appear in the two conditions of simulated and

TABLE 8-1

MAJOR DIFFERENCES BETWEEN LTV ABORT SIMULATION AND ACTUAL ASCENT SITUATION

FACTOR	PRESENT IN LTV SIM.	PRESENT IN ACTUAL ASCENT
Seated "Launch" Position	Partially	Yes
Full PSA	No	Yes
Acceleration Loads	Limited	Yes
Pilot Performing Tasks Unrelated to Abort	Limited	To a greater degree
High Mental Stress	Limited	Yes
Body Disorientation	Limited	Perhaps
Expectation that Abort is Likely	Yes	No
Knowledge of Hazards Involved in Leaving Spacecraft	No	Yes
Knowledge of Hazards Involved in Staying with Spacecraft	No	Yes
Practice Just Prior to Recorded Abort	Yes	No
Full level of C/M Training	No	Yes

8. (Continued)

actual flight. The quantitative influence of these factors on crew escape performance is not easily defined.

Although it is not possible to weight each of the factors listed in Table 8-1, it can be stated that they are not of equal significance. For example, a high level of crew training and motivation could render the contribution of several factors insignificant. However, after close examination of the major factors in their proper perspective, it seems more probable that there would be some net decremental effect under actual abort conditions.

Section 7.2.1 notes that sixteen Mode B primary data points are identified as premature "violation of procedure" responses even though safe escape in these specific situations was possible. The time allowed for crew training was adequate for the purposes of the LTV simulation. The crewmen were quick to grasp the nature of the simulation and the procedures required. But level of familiarization and training achieved at LTV in no way approaches the level of crewman training expected at launch time. A more comprehensive exposure to all malfunctions and the expected amount of training involved for the crew by first manned flight would essentially eliminate premature responses of this nature. Consequently, it is felt that the responses recorded prior to 200 milliseconds after RATE light activation in the primary Mode B data would be atypical of a well trained crewman in the actual abort situation.

8.1 Crew Response Time Models - The ejection time response characteristics as given in Figures 7-1 and -2 constitute the engineering models of crew performance to be used in Mode A escape analyses. The figures show response time referenced to escape initiation time, which was used in this analysis to

8.1 (Continued)

correlate crew responses with the escape windows. As a response time model, however, the only invariant characteristic is the response time interval after the cue is given. In future applications with the EJECT light, the time selected for light illumination may be varied as required to orient the responses with respect to a given escape action window. Likewise, without the EJECT light the distribution of responses will be fixed with respect to retro-rocket burnout time which serves as the dominant cue source.

For Mode B escape initiation, Figures 7-15 and -16 show the engineering models for response time with respect to cue activation (RATE light). The appropriate model is selected according to the procedure in question, and the response distributions are fixed with respect to a given escape window through choice of the pitch-rate threshold that activates the cue. The SRM burnthrough-augment malfunction causes a unique set of response characteristics that varies with respect to cue time as a function of rate threshold. The Mode B data originally included responses that apparently were performed in violation of the prescribed escape procedures. These responses have been excluded from the distributions in these models.

The response time characteristics for the procedure using the FDI as a cue, shown in Figure 7-17, are not recommended for general use as an engineering model. These characteristics are based on a limited amount of data with an extemporaneous test set-up that does not permit thorough analysis nor yield high confidence in the statistical validity of the results.

8.2 Evaluation of Escape Procedures

8.2.1 Mode A - The two procedures tested, with and without the EJECT light, both permit the crew to always eject within the 1.0 second window that provides

8.2.1 (Continued)

100 percent safe-escape probability for pad aborts and to meet the minimum eject time requirement for aborts after lift-off.

The ejection timing cue based on kinesthetics is not uniquely defined. It is identified by the changes in acceleration and noise level at retro-rocket burnout. The acceleration change is predictable analytically but the LTV simulation accelerations were, by necessity, limited in magnitude by the requirement to produce linear and angular effects simultaneously within the gimbal angle constraints. The noise levels at LTV were conjecture with respect to retro-rocket burnout. Additional effects from vibration and other environmental factors were not present. The total time spread in the Cue 1 data was 600 milliseconds, which leaves some margin to accommodate a decrease in window size or any possible degradation due to unsimulated effects.

The EJECT light produced a compression of the responses into a smaller time span, but unless subsequent escape analyses show a substantial reduction in window size, this compression is unnecessary.

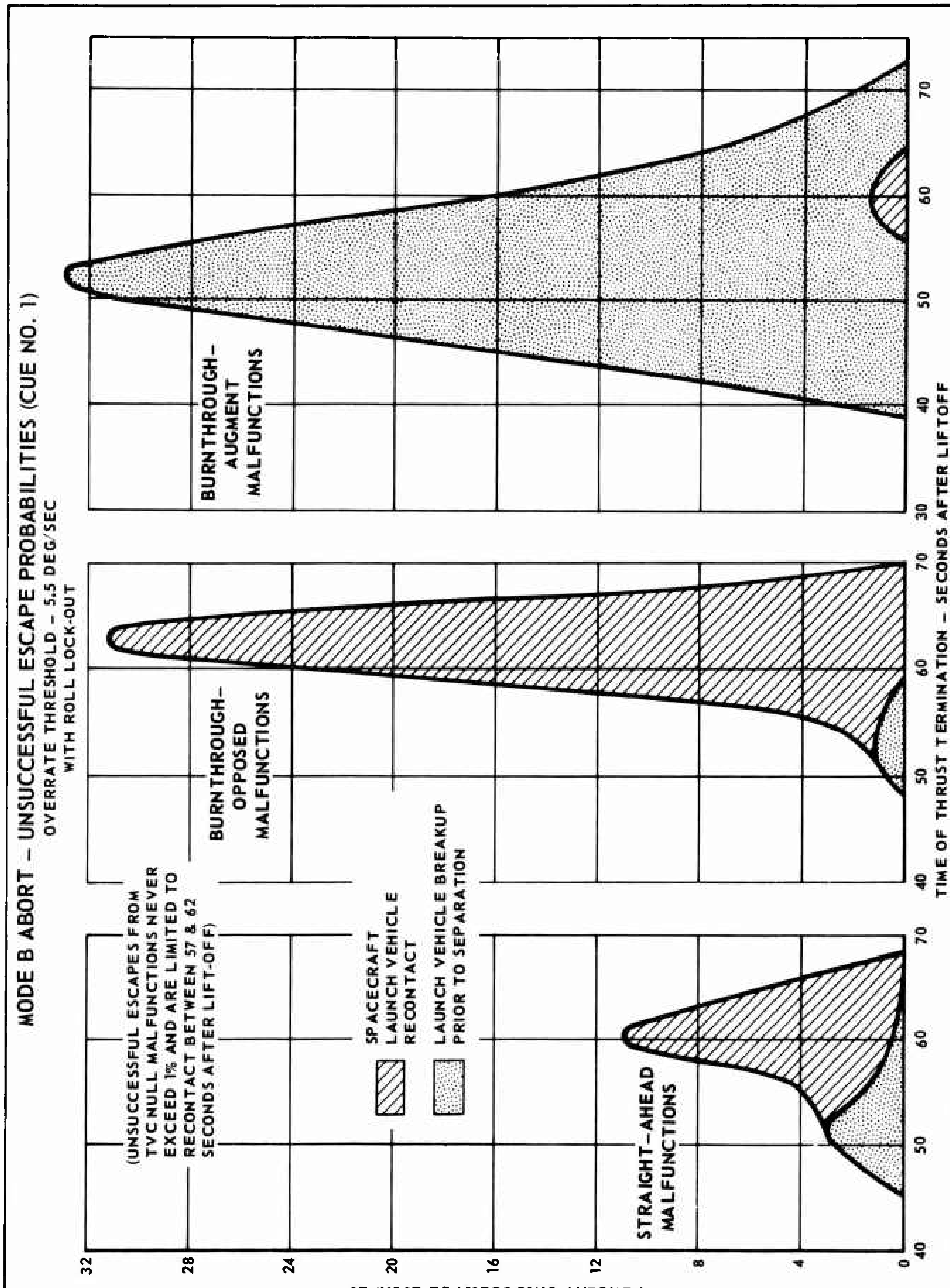
8.2.2 Mode B - The analyses of the test data have developed the basic crew response time characteristics for escape initiation as given in Figures 7-15, -16, and -17 for the three variations of escape procedure tested. In order to complete the primary test objective, these response characteristics must be evaluated with respect to the escape windows with a view toward defining the best overall procedure. The basis of this evaluation will be the probabilities of unsafe escapes incurred by each procedure.

The Cue 1 procedure encompassed the most exacting task since the crew not only had to cope with achieving escape initiation within a small safe escape window, but they also had to delay initiation in order to center the median

8.2.2 (Continued)

response in the window. The percentage of responses expected to be unsafe at a given thrust termination time is found by comparing the escape window boundaries at that TT time with the Cue 1 response time distribution (Figure 7-15). The expected percentages, or probabilities, of unsafe escape occurrences are shown for Cue 1 in Figure 8-1. The SRM burnthrough malfunctions show peak unsafe escape probabilities of 31 and 33 percent for the opposed and augment cases, respectively. The straight-ahead malfunctions show a maximum of 11 percent, and the TVC null malfunctions never incur greater than one percent. Although the burnthrough malfunctions result in nearly the same percentages unsafe, the opposed burnthrough is affected more by the early boundary (recontact) while the augment burnthrough has nearly all its unsafe occurrences at the late boundary (launch vehicle breakup). This indicates that the crew were achieving a median response very near the center of the escape action window in accordance with the procedure. No improvement in performance would be expected for a different rate threshold under the same procedure.

For the Cue 2 simulations the RATE light cue time was increased in order to minimize the probability of recontact boundary violations. The crew no longer delayed initiation and a skewed response distribution resulted, in which the greater percentage of data fall in the early portion of the time spread. Figure 8-2 shows the expected probabilities of unsafe escape occurrence with the rate threshold at the 8.0 degree/second value selected for the Cue 2 simulations. The burnthrough-augment malfunctions are once again seen to cause large probabilities of unsafe escape with a peak of 41 percent. The burnthrough-opposed and straight-ahead malfunctions incur maximums of only about 4 percent unsafe, while the TVC nulls show a peak of 14 percent. In contrast to the Cue 1 procedure, these



MODE B ABORT – UNSUCCESSFUL ESCAPE PROBABILITIES (CUE NO. 1)
OVERRATE THRESHOLD – 5.5 DEG/SEC
WITH ROLL LOCK-OUT
BURNTHROUGH–AUGMENT MALFUNCTIONS
BURNTHROUGH–OPPOSED MALFUNCTIONS
STRAIGHT-AHEAD MALFUNCTIONS
(UNSUCCESSFUL ESCAPES FROM TVC NULL MALFUNCTIONS NEVER EXCEED 1% AND ARE LIMITED TO RECONTACT BETWEEN 57 & 62 SECONDS AFTER LIFT-OFF)
SPACECRAFT LAUNCH VEHICLE RECONTACT
LAUNCH VEHICLE BREAKUP PRIOR TO SEPARATION
PERCENT UNSUCCESSFUL ESCAPES
0
4
8
12
16
20
24
28
32
TIME OF THRUST TERMINATION – SECONDS AFTER LIFTOFF
30
40
50
60
70

FIGURE 8–1

MODE B ABORT

UNSUCCESSFUL ESCAPE PROBABILITIES (CUE NO. 2)
OVERRATE THRESHOLD – 8.0 DEG/SEC
WITH ROLL LOCK-OUT

NOTE: ONLY THE LAUNCH VEHICLE BREAKUP BOUNDARY IS VIOLATED

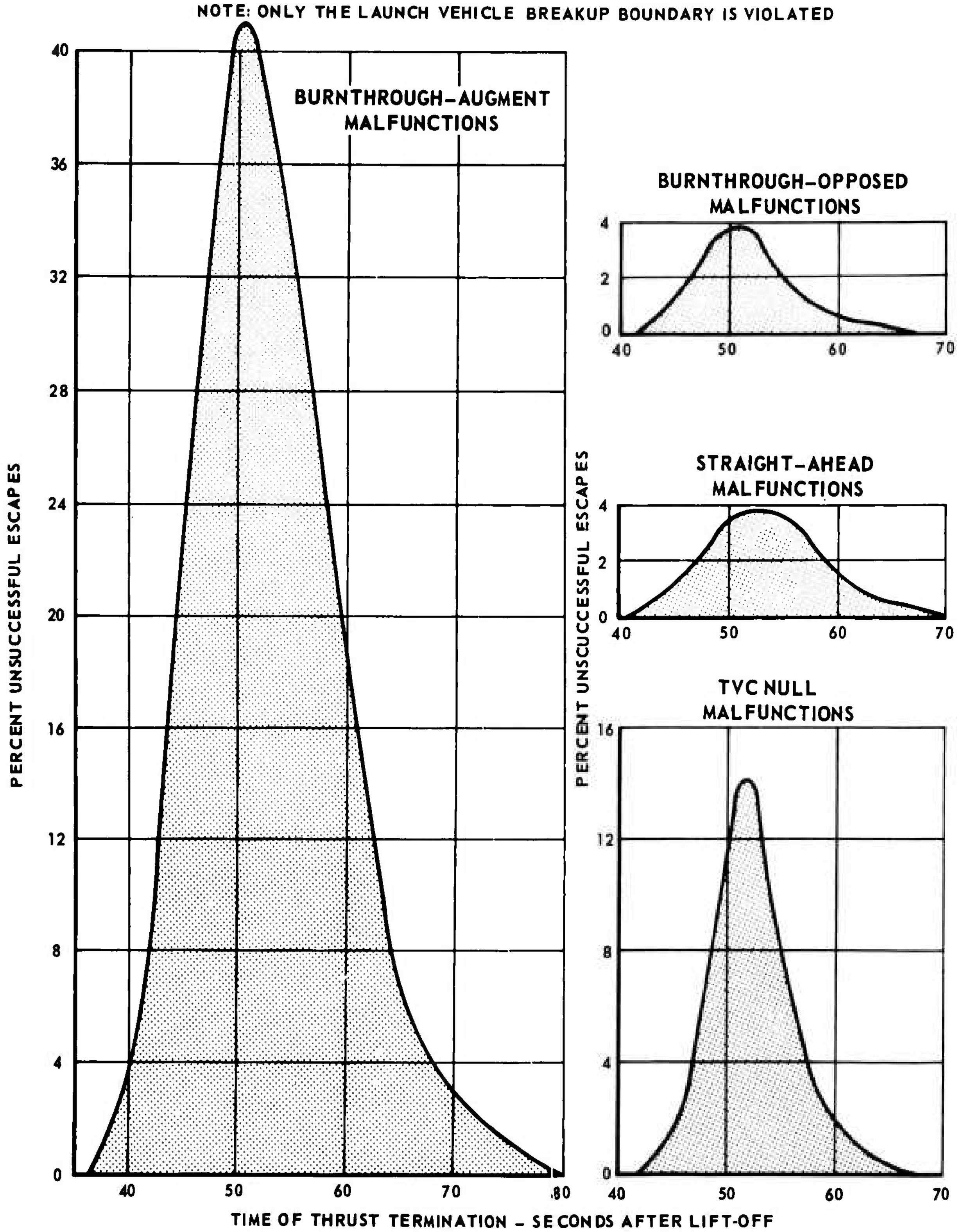


FIGURE 8-2

8.2.2 (Continued)

unsafe escape occurrences all result from violations of the launch vehicle breakup boundary. Thus the probabilities of unsafe escapes would be expected to decrease if the RATE light cue time is decreased.

In finding an optimum RATE light setting for Cue 2, consideration must be given to the effect of RATE light cue time on the response characteristics for the burnthrough-augment malfunctions. As discussed in Section 7.2.2, the response time characteristics for the burnthrough-augment malfunctions are displaced with respect to the response times for all other malfunction types. The reason for this displacement lies in the rapid divergence rate build-up after thrust termination, causing the rate threshold to be achieved near the time when the crewman is completing his initial abort action of advancing the abort handle to the SHUTDOWN position. Figure 8-3a shows the escape initiation response time after the RATE light as a function of the time interval (T_1) between achievement of the SHUTDOWN position and RATE light on. Responses for both Cue 1 and Cue 2 are included in this plot. Crew comments made during the Cue 1 runs indicated that they were not delaying escape initiation for these malfunctions because of the fast RATE light. This is substantiated by Figure 8-3a since the data for both Cue 1 and Cue 2 coincide in trend and magnitude where they overlap. It was also found that the total abort action time (ABORT light to ABORT position) is the same for both cues. This figure, then, is the indicator of losses to be expected in escape initiation response time when the RATE light comes on near, or prior to, achievement of the SHUTDOWN position. The confidence in determining from this plot a firm trend to use as a criterion for response time adjustment when the rate threshold is changed is limited, however, because of the scatter in response times and the small data distribution with variations in T_1. To shore-up this

EFFECT OF RATE LIGHT CUE TIMING ON ESCAPE INITIATION RESPONSE TIME

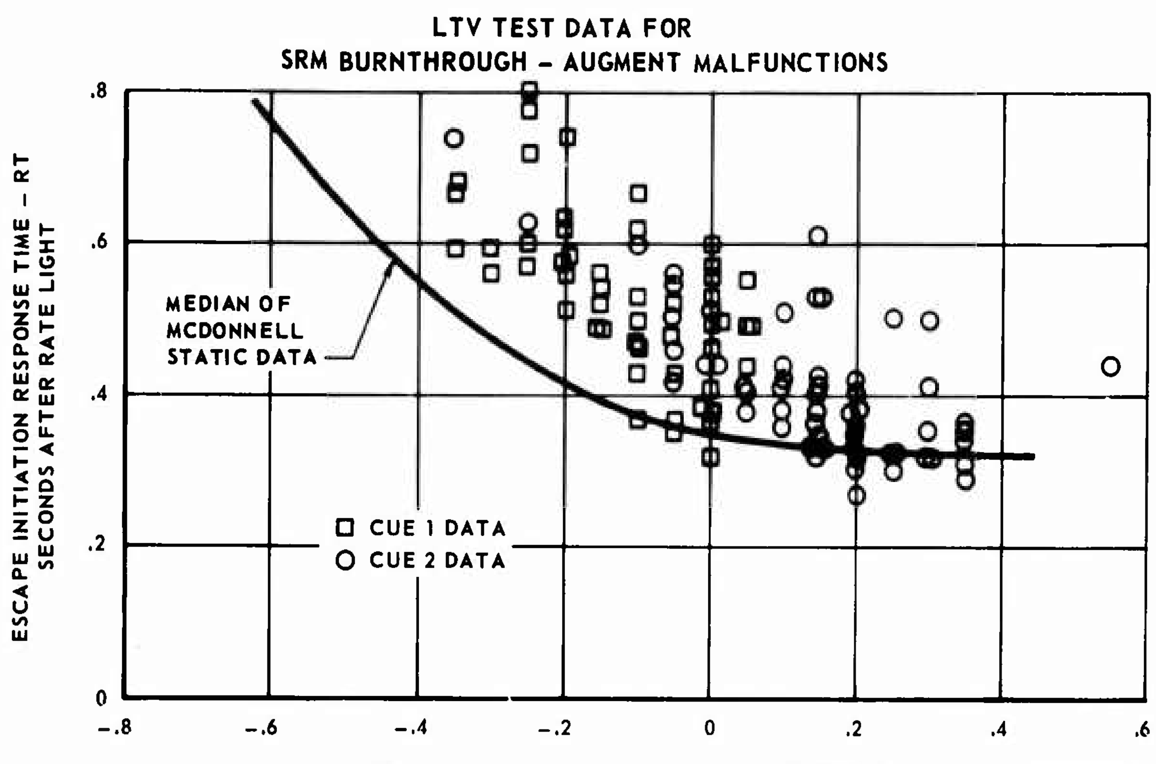


FIGURE 8-3 a

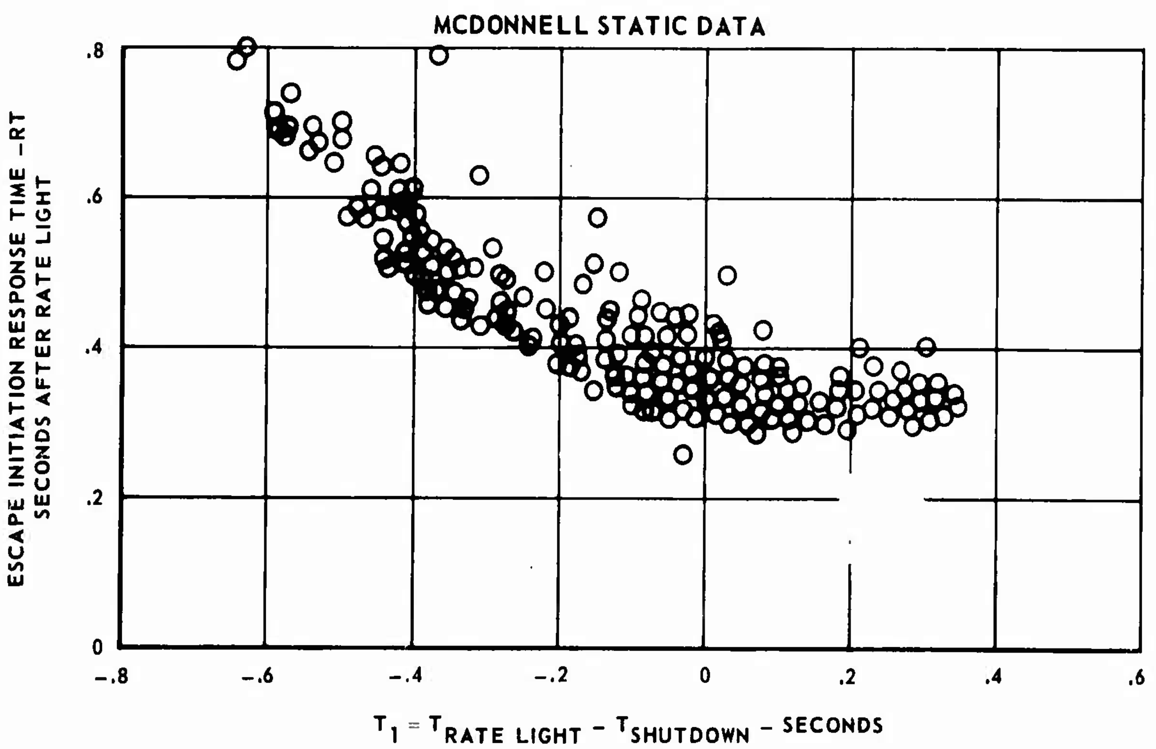


FIGURE 8-3 b

8.2.2 (Continued)

confidence, a set of static response data were measured by McDonnell Astronautics Company after completion of the LTV simulation (Section 6.3). These data are plotted in Figure 8-3b. As is typical of static data, the variation in response times is considerably less than the dynamic test data; nevertheless, a clear trend is observed in the variation with T_1. Also, the minimums in these static data define the lower limit for responses in the dynamic situation. When the median curve from these static data is superimposed on the LTV test data in Figure 8-3a, an unexpected effect is seen. The range (scatter) of responses for the test data increases as the RATE light comes on progressively earlier, so that the median trend for the LTV data appears to diverge from the static data median rather than being merely displaced from it as might be expected. No reason has been identified as to the cause of this divergence, and it can only be assumed to result from the disconcerting effect on the crew when the very early RATE light occurs among the randomly presented test cases. As a result the static data do not, as hoped, provide a useful improvement in the ability to estimate the change in response time displacement with variations in RATE light timing. The estimate must therefore be made by interpolating between the burnthrough-augment median response time (390 milliseconds) with Cue 2 and the Cue 1 median (515 milliseconds) for rate thresholds of 8.0 and 5.5 degrees/second, respectively. The following formula calculates this displacement as an increment from the Cue 2 responses for all malfunctions (except burnthrough-augment) for use in rate threshold optimization.

$$\Delta RT = 0.400 - 0.05\,\dot{\theta}$$

where ΔRT = increment of response time between burnthrough-augment and all other malfunctions for Cue 2, seconds

$\dot{\theta}$ = rate threshold, degrees/second

8.2.2 (Continued)

With this estimate of the effect of rate threshold variations on response time characteristics, it is now possible to set forth a method for determining the optimum rate threshold. The optimizing procedure should consider all malfunction types and their probability of occurrence as a function of TT time. For each of several rate thresholds the probabilities of unsafe escape are prepared as in Figure 8-2. The probabilities for each malfunction type are then adjusted by a weighting factor to reflect the relative probability of each malfunction occurring. The adjusted probabilities are then summed at constant TT times and the sums plotted as a function of TT time. The area under each curve (λ) is then computed and plotted versus rate threshold. Since λ combines all the effects that influence safe escape it serves as an optimizing parameter.

The relative probabilities of occurrence for each of the malfunctions were not available at the time of report preparation; therefore, only an example of the above process can be shown. Figure 8-4 shows the variation of λ with rate threshold for the Cue 2 response distributions assuming equal probability of occurrence for each malfunction type. Figure 8-5 shows the probabilities of unsafe escape expected with this pseudo-optimum rate threshold for Cue 2.

It would appear that the optimizing method can produce the proper balance of risk among the malfunction types. Without the proper weighting factors, however, it is not possible to draw final conclusions as to the overall adequacy of the Cue 1 and Cue 2 procedures, which was the desired end product of the simulation and post-test analysis. The relative comparison between these cues does indicate an improvement in risk for all malfunctions except burnthrough-augment when Cue 2 procedures with an optimum rate threshold are employed. The insensitivity of the burnthrough-augment is the result of the limitations imposed by minimum abort

MODE B
OPTIMIZATION OF RATE THRESHOLD FOR CUE 2 ESCAPE PROCEDURE

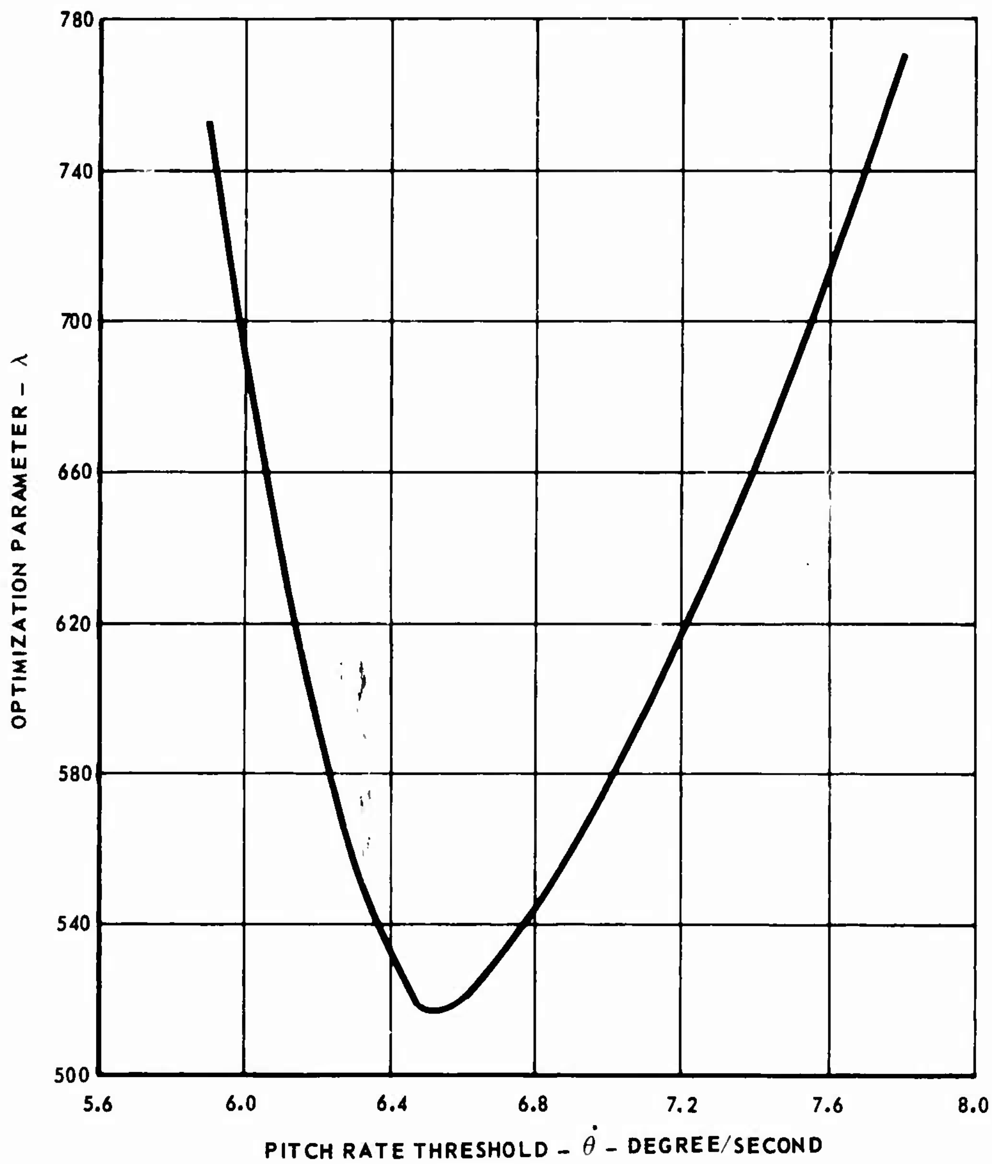


FIGURE 8-4

MODE B

UNSUCCESSFUL ESCAPE PROBABILITIES
CUE 2 ESCAPE PROCEDURE
PSEUDO-OPTIMUM RATE THRESHOLD OF 6.5 DEG/SEC

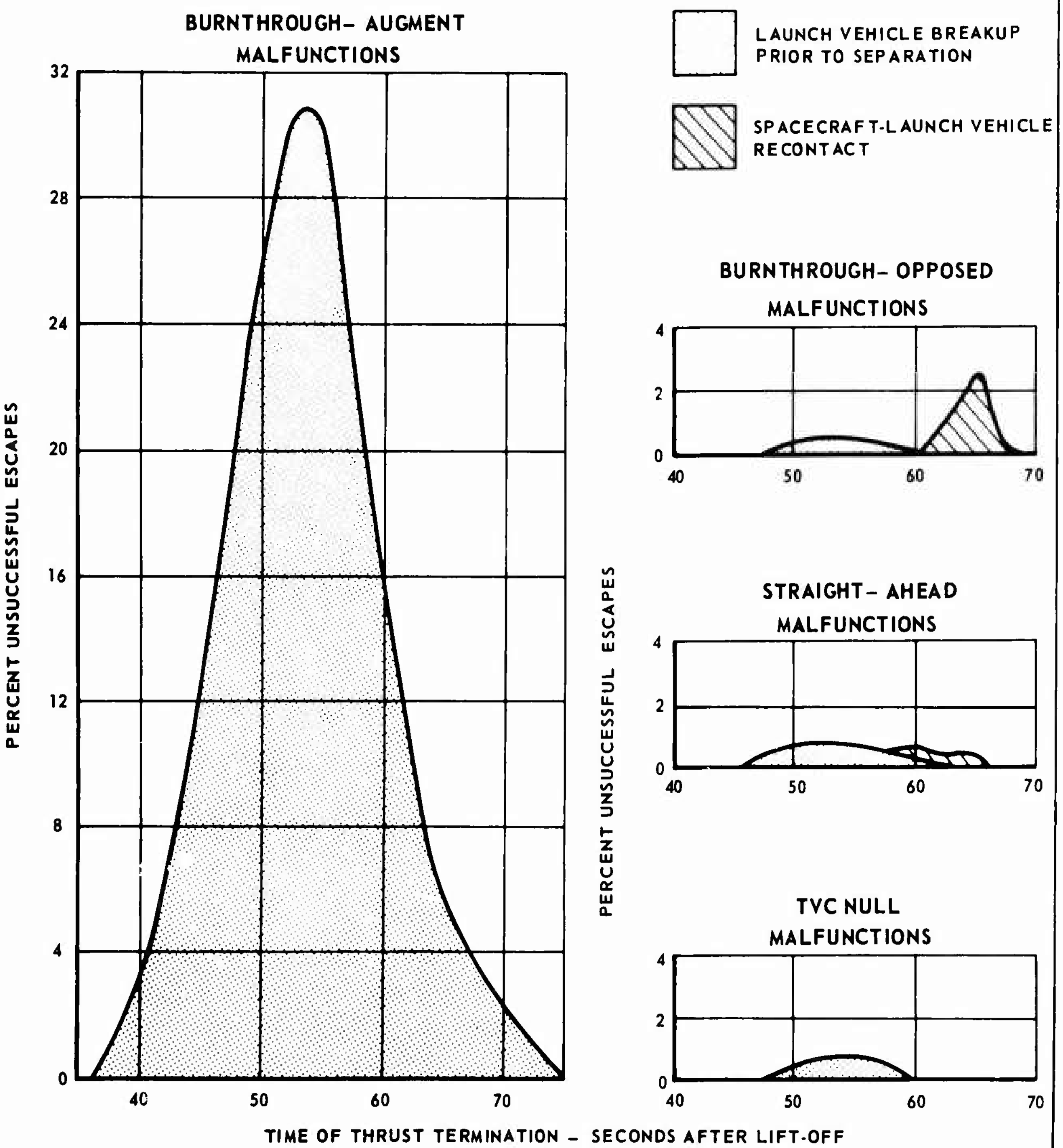


FIGURE 8-5

8.2.2 (Continued)

handle travel time and the rapid divergence rate build-up after TT, neither of which can be altered by cue or procedural changes. It must be noted that the particular burnthrough-augment malfunction that was simulated was a "worst-case" condition, specifically chosen for the crew safety analyses to define a limit divergence-rate condition. When the relative probabilities of occurrence are determined the significance of the unsafe escapes for burnthrough-augment should be quite small.

The Cue 3 procedure was included for the secondary test objective (display evaluation), with the original purpose being to examine use of the FDI to back up the RATE light. However, the crew found that the FDI needles in themselves were a sufficient cue and responded only to the rate index whether or not the RATE light came on. Consequently, the Cue 3 responses are the result of the FDI providing the cue for escape initiation and thus constitute a separate set of results in which the crew response characteristics appear to accommodate the escape action requirements to a more satisfactory degree than either the Cue 1 or 2 procedures.

Figure 8-6 shows the probabilities of unsafe escape occurrence derived from the Cue 3 response characteristics. The burnthrough-augment malfunctions still cause the greatest percentage of unsafe escapes; however, the maximum is only 16 percent. Further detailed analyses of the response characteristics or evaluation of the procedure at this time is not warranted in view of the data sample size and test set-up. A more extensive collection of data, using an FDI unit properly configured for this procedure, would be necessary to verify these results and provide a more comprehensive engineering model of the crew response characteristics.

MODE B
UNSUCCESSFUL ESCAPE PROBABILITIES (CUE NO. 3)
FDI HIGH RATE SETTING
OVERRATE THRESHOLD – 8.0 DEG/SEC
WITH ROLL LOCK-OUT

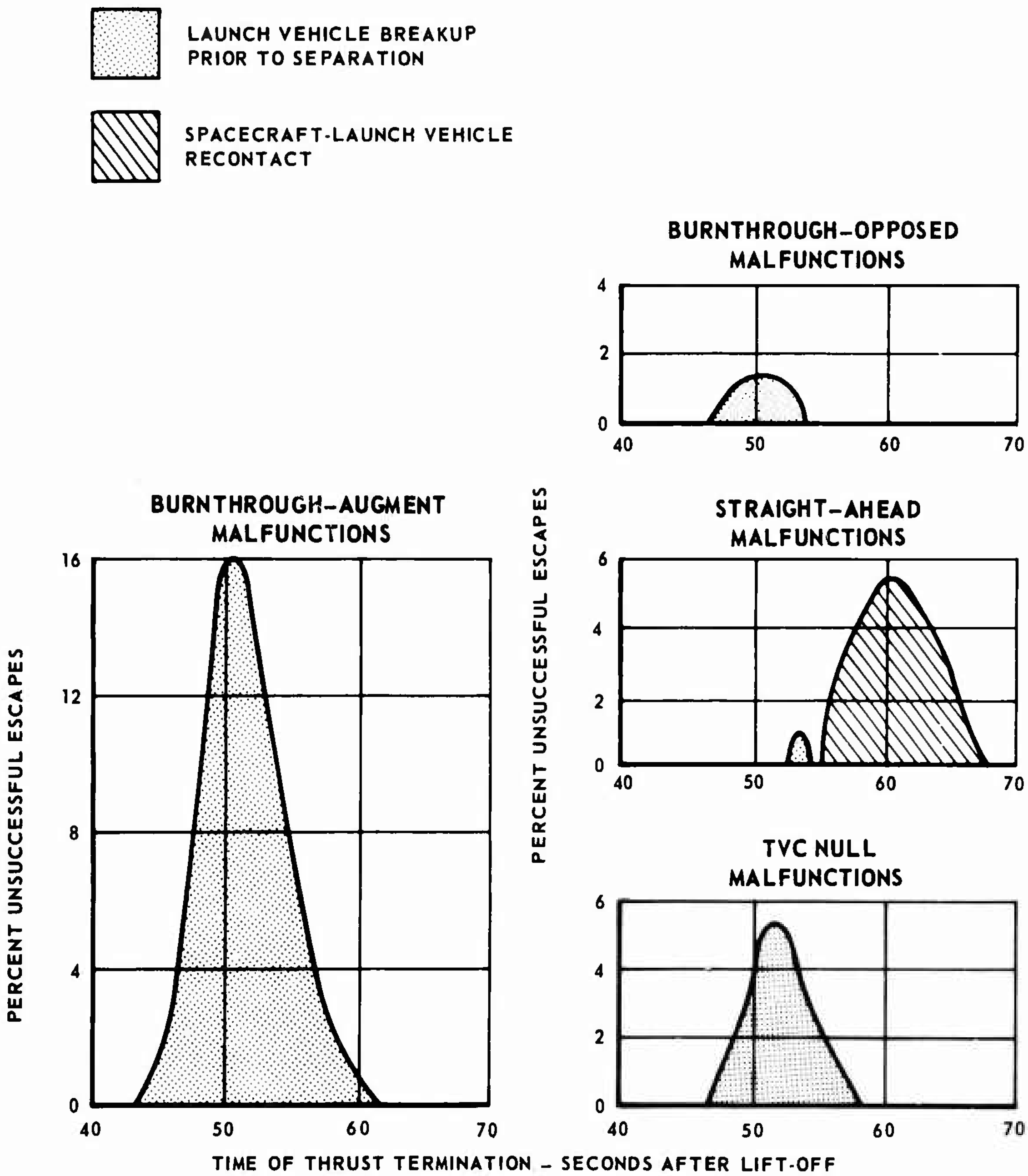


FIGURE 8-6

8.3 Evaluation of Crew Displays - The suitability of the Gemini B abort displays and controls was demonstrated by the MOL crewmen during the LTV simulation. It was verified that the crew had the capability to anticipate most of the failures and apply the required abort/escape procedures. Certain cases, such as single SRM ignition and TVC null malfunctions, develop so rapidly that they require immediate response to discrete displays without the benefit of anticipation. The anticipation of an abort condition is of primary concern when an instrumentation system is developed. It shows that the crewman is receiving the critical parameters in a manner that allows him to analyze and retain the current trends as they are developing. The decision making process uses analog displays with suitable calibrations and indices to represent the collected data. On the other hand, if the crew station displays were to rely on discrete indicators for such information, this decision making process is eliminated. The crew no longer has the information and trend data necessary to anticipate a pending failure requiring an abort decision.

During the simulation program various crew comments were collected concerning the abort displays. These comments have been reviewed and will be discussed individually.

A. Interference of the Gemini Hatch Beam with Guidance lights on the Left Main Instrument Panel was noted by the crew. The problem resulted from the use of the NASA Gemini instrument panel installed in the gondola (Section 4.2.3) which positioned the lights 1/2 inch higher than the Gemini B position. Padding on the seat used in the simulator also contributed somewhat to this obstruction. A representative of the crew has since examined the ECV at McDonnell and verified that these lights are

8.3 (Continued)

visible in the Gemini B configuration.

B. Specific comments on the lack of contrast of the flight director needles, when viewed against the attitude ball, have been examined. An increase in contrast by painting the needles "dayglow orange", as suggested by the crew, can be incorporated, if desired. The needles would still be graduated in five increments and the increased contrast would improve readability. An additional comment suggesting a rate reference mark on the attitude display director needles was generated during the secondary objective runs at LTV. The purpose of these runs, as described in Section 3.3, was to verify the ability of the crew to sense an overrate condition by referring to the rate needles on the attitude indicator. In order to provide a threshold reference, a tape index was attached to the face of the indicator and was used in conjunction with the spacecraft yaw needle (launch vehicle pitch). This method introduced a parallax error that was evident to the crew. This problem can be resolved by incorporating the index mark on the spacecraft pitch needle. This change could be incorporated at the same time the color of the needles is changed.

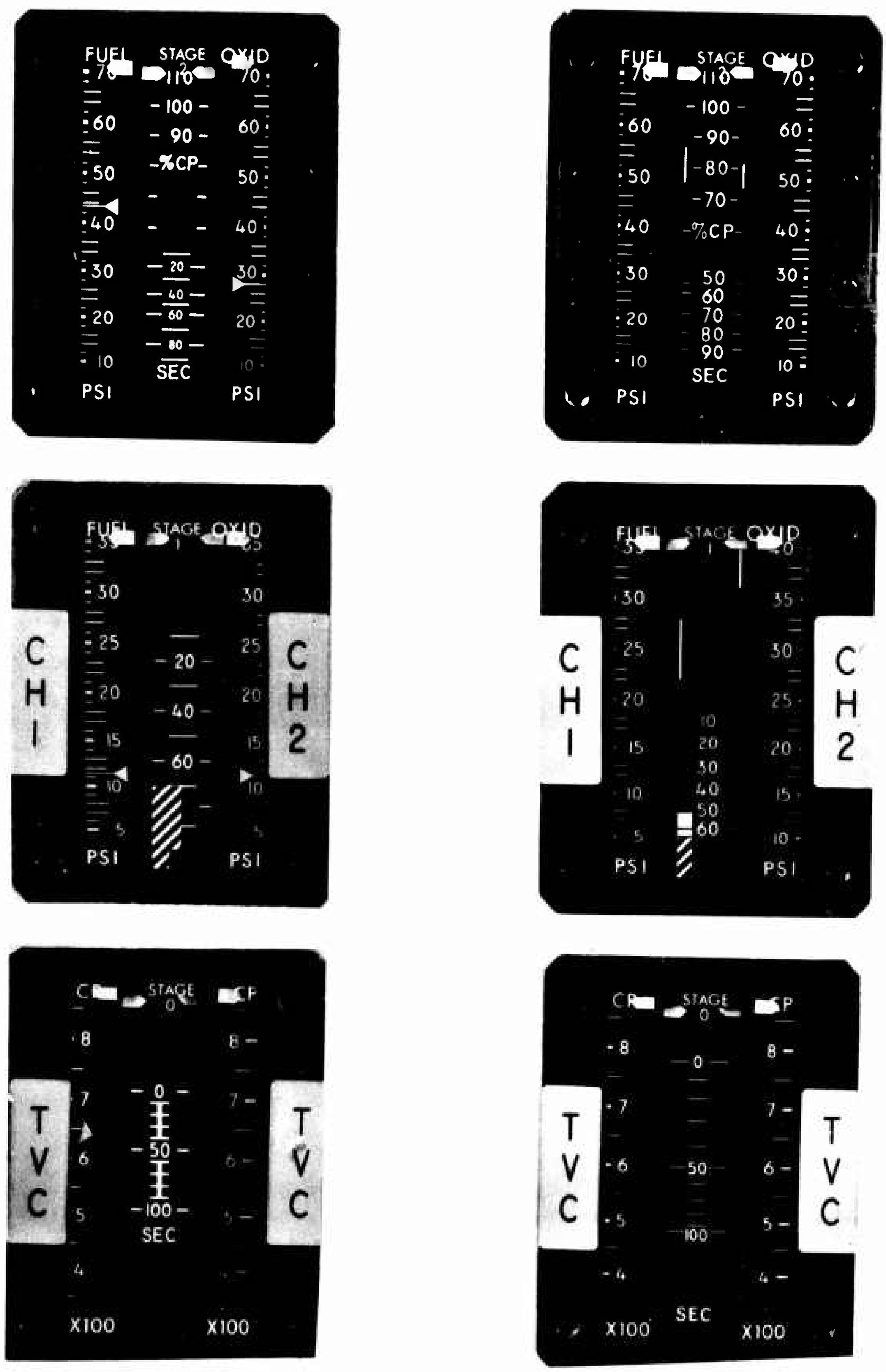
C. Crew reaction to the launch vehicle instrumentation and displays was favorable. One specific area of concern, however, was that the Stage I oxidizer pressure needles were driven off scale during the simulation. The meter was calibrated to a maximum pressure of 35 psi and the simulation program was driving the meter to 38 psi. Changes in launch vehicle data require a revision in meter calibration for the flight vehicles that differs from what was displayed during the LTV simulation. The new data, however, will be displayed using the same format as used during the crew

8.3 (Continued)

runs and the malfunction-detection and analysis tasks that were simulated will remain unchanged. These scale revisions are not considered to have a serious effect on the proper use of the instrumentation and, therefore, the LTV data is representative of the conditions that will exist for manned flight. Figure 8-7 shows a comparison of the meters as used in the simulation and the revised meters as configured to incorporate the new data. Figure 8-8 presents the updated nominal pressure-vs-time profile for the Stage "O" SRM's. Figures 8-9 and -10 illustrate the relation of the time scale calibrations and the critical structural limits. The configurations provide a suitable reference for abort malfunction detection and analysis. They retain a common time reference as requested by the flight crew which was achieved through alteration of the Stage I oxidizer display range from 5-35 psi to 10-40 psi for the Stage I meter. The common time reference for the Stage II meter was achieved through basing the time hacks on the critical fuel tank and permitting additional margin on the oxidizer pressures. Nominal lock-up pressure ranges are also incorporated in the proposed meter configurations, as shown in the figures. Reference (5) proposes incorporation of these changes.

D. Crew comments on the warning light modules associated with the Stage I pressure indicator were evaluated with respect to the ability to detect single bulb extinguishment similar to the failure case utilized in the LTV simulation. Two versions of the warning light assembly were evaluated as shown in Figure 8-11. The first of those evaluated was like the units used in the gondola at LTV, and herein identified as Exhibit A. The second unit evaluated was provided by Lear Siegler, Inc. in response

A



OLD

NEW

FIGURE 8-7

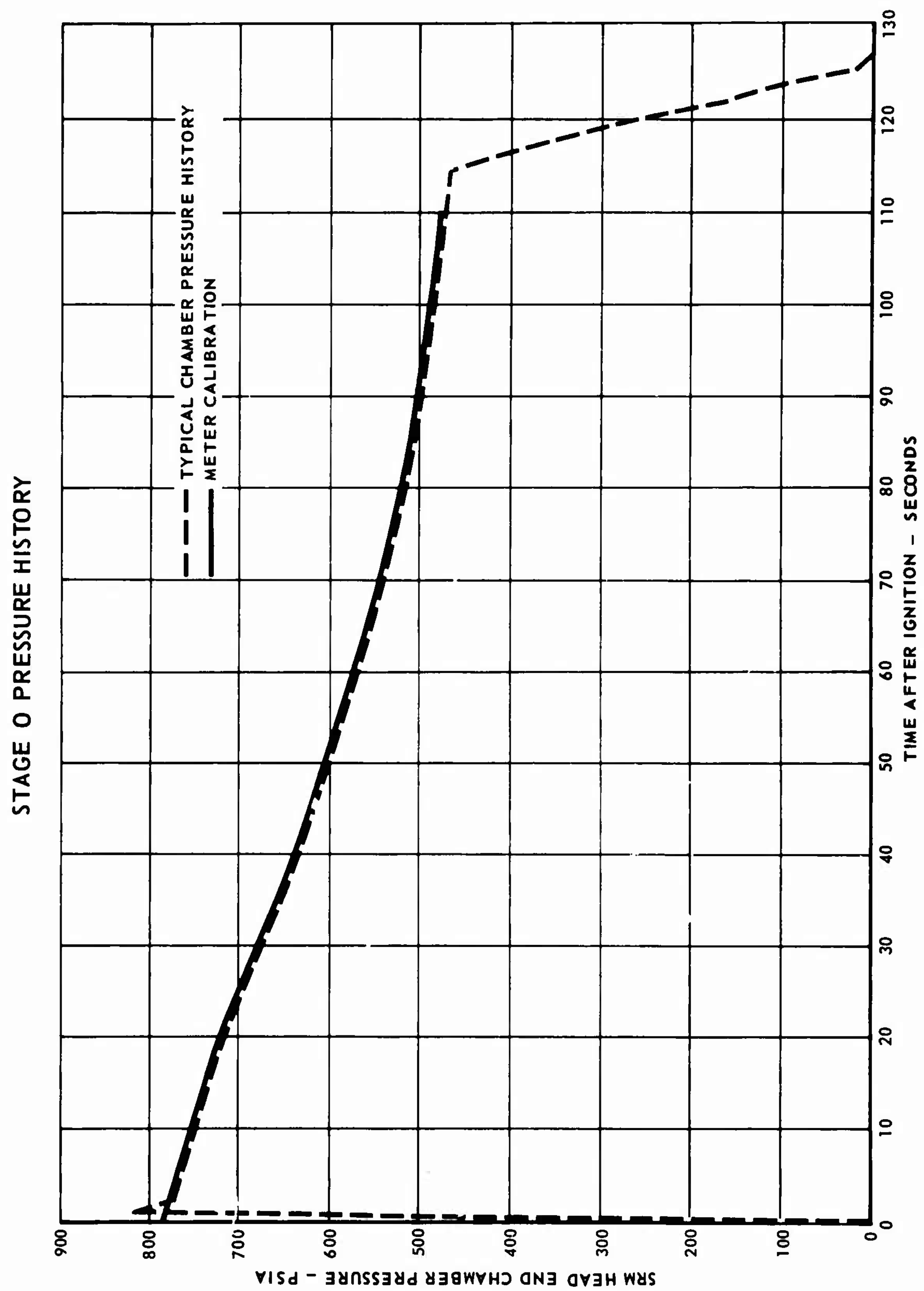

STAGE O PRESSURE HISTORY
TYPICAL CHAMBER PRESSURE HISTORY
METER CALIBRATION
TIME AFTER IGNITION - SECONDS
0
10
20
30
40
50
60
70
80
90
100
110
120
130
SRM HEAD END CHAMBER PRESSURE - PSIA
900
800
700
600
500
400
300
200
100
0

FIGURE 8-8

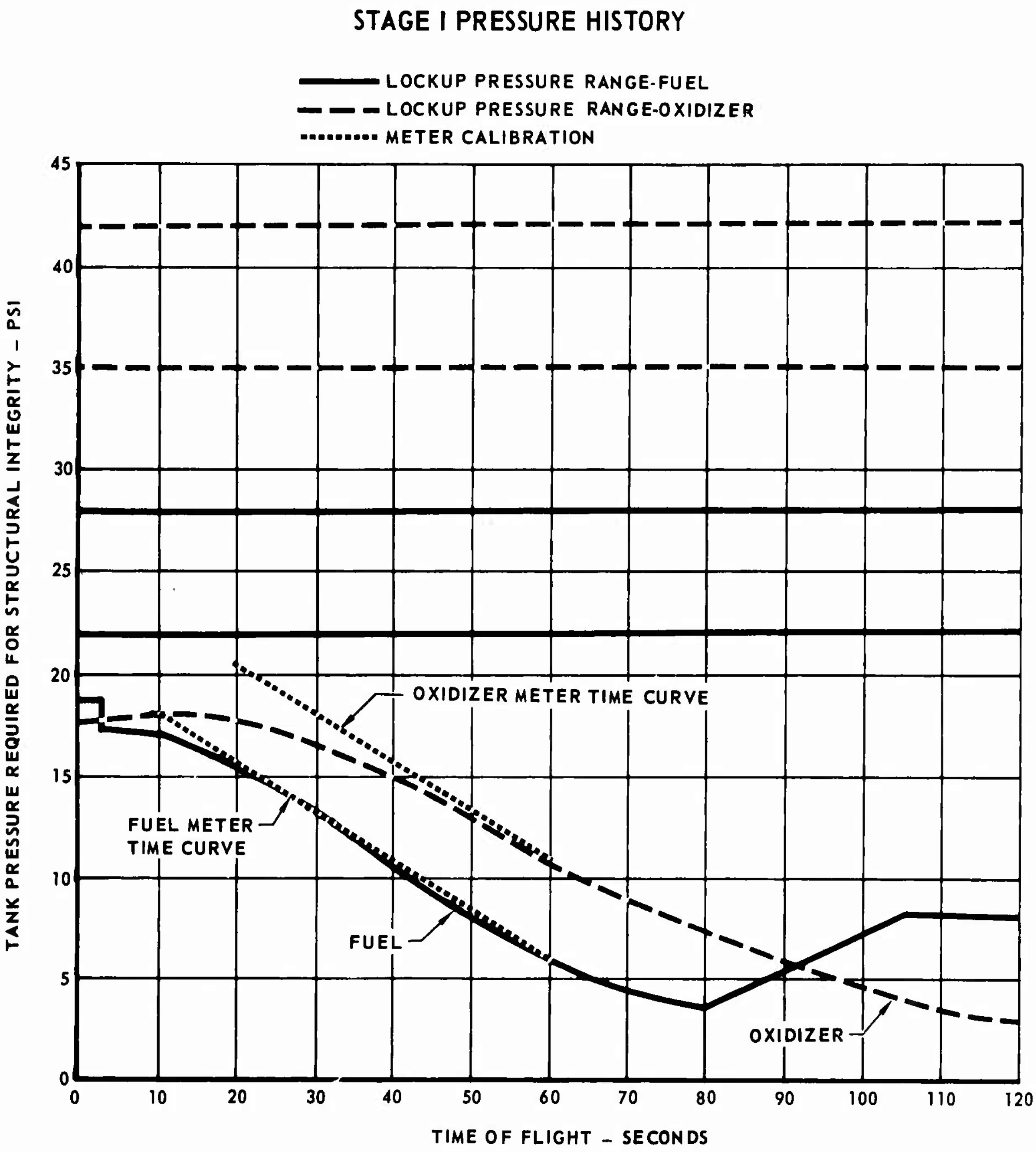

STAGE I PRESSURE HISTORY
LOCKUP PRESSURE RANGE-FUEL
LOCKUP PRESSURE RANGE-OXIDIZER
METER CALIBRATION
OXIDIZER METER TIME CURVE
FUEL METER TIME CURVE
FUEL
OXIDIZER
TANK PRESSURE REQUIRED FOR STRUCTURAL INTEGRITY – PSI
TIME OF FLIGHT – SECONDS
0
5
10
15
20
25
30
35
40
45
0
10
20
30
40
50
60
70
80
90
100
110
120

FIGURE 8-9

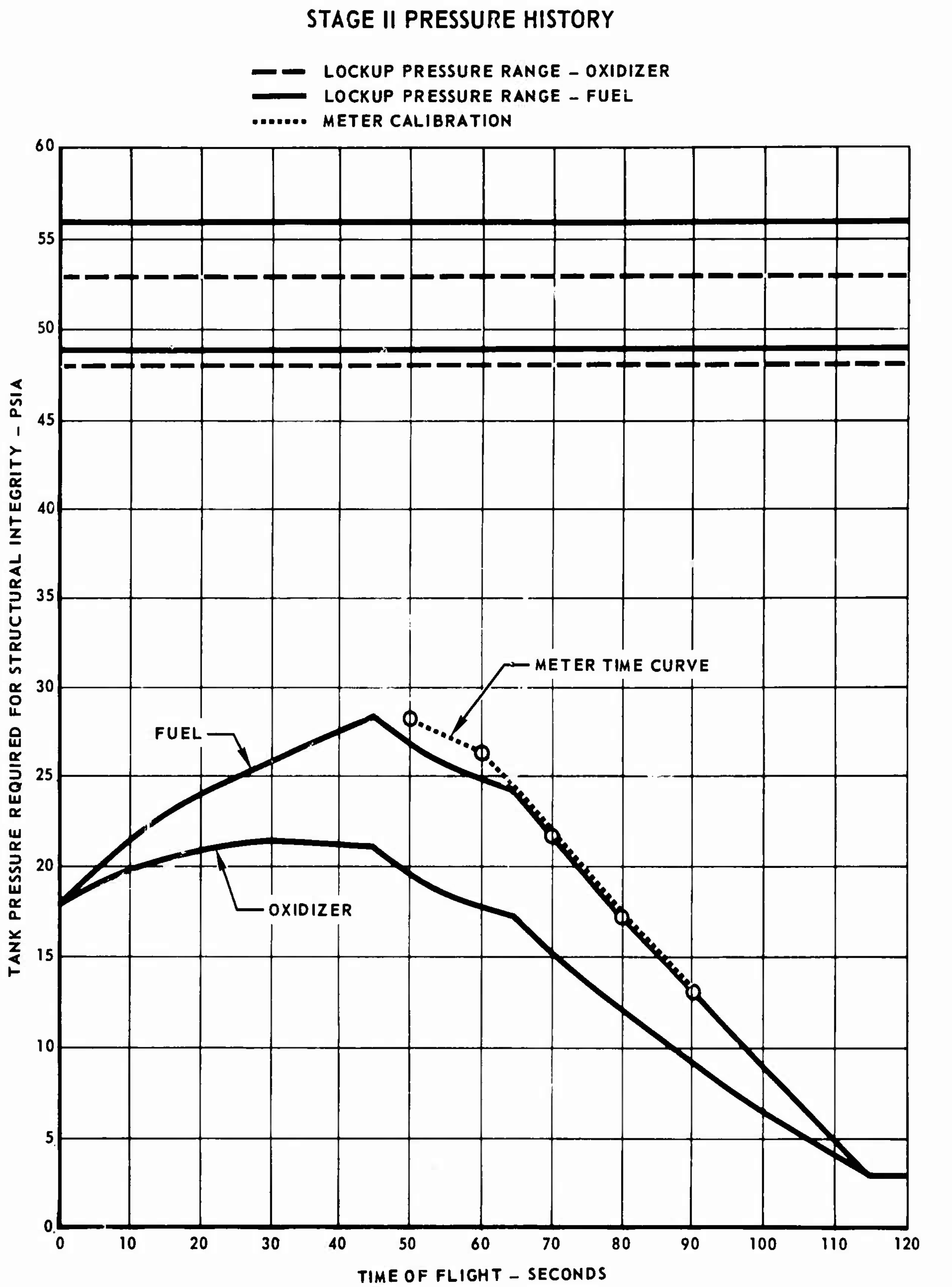
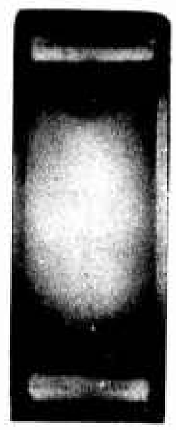

STAGE II PRESSURE HISTORY
LOCKUP PRESSURE RANGE – OXIDIZER
LOCKUP PRESSURE RANGE – FUEL
METER CALIBRATION
METER TIME CURVE
FUEL
OXIDIZER
TANK PRESSURE REQUIRED FOR STRUCTURAL INTEGRITY – PSIA
TIME OF FLIGHT – SECONDS
0
5
10
15
20
25
30
35
40
45
50
55
60
70
80
90
100
110
120

FIGURE 8-10

EVALUATION OF WARNING LIGHTS
PHOTOGRAPHIC SUMMARY OF TEST RESULTS

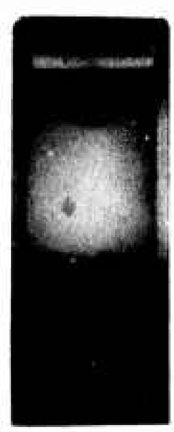
EXHIBIT A
AS PROVIDED FOR TEST
TWO BULBS ON

EXHIBIT B
AS PROPOSED
TWO BULBS ON



ONE BULB ON

ONE BULB ON



(EXCITATION VOLTAGE 24 VDC)

FIGURE 8-11

8.3 (Continued)

to a telephone inquiry made in January 1968. That inquiry was made to establish the degree of fidelity in the mock-up light modules used on the simulator units. L.S.I.'s response indicated that the units provided were representative of "production", but also indicated that additional light separation would be relatively easy to achieve. Exhibit B is a sample of the unit with this additional light separation.

The ability to detect single bulb extinguishment was enhanced significantly by modification of the light separator as displayed in Exhibit B.

The conclusion of this warning light evaluation is that the configuration shown in Exhibit A does not provide adequate light separation to detect single-bulb-out conditions when employed in the launch vehicle monitor and abort detection system. However, the warning light configuration identified as Exhibit B provides more than adequate light separation to insure detection of single-bulb-out operation by the flight crew.

Since the light module used in the Stage I chamber pressure warning lights is common to the Stage "O" indicator TVC lights it would be logical to provide the same light separation for the TVC warning lights.

E. The event timer is a multipurpose device used in all phases of Gemini B occupancy. It is used as a time reference during the ascent phase and as such was included in the LTV simulation. The configuration of the readout in minutes and seconds, which is identical to the NASA configuration, best meets all of its requirements for use throughout the mission. Some comments were received that indicated concern over the fact that the event timer readout is in minutes and seconds while the time hacks on the

8.3 (Continued)

tank gauges are in seconds, thus requiring the crewman to convert time, which seemingly is an unnecessary task.

However, this situation would not appear to compromise crew use when the procedures during ascent are fully examined. During ascent the right-hand crewman will monitor the eight day clock on the center instrument panel and call off 10-second time hacks to the left-hand crewman. The launch control center will provide time hacks, abort mode changes, and launch vehicle discrete functions to the crew for comparison and cross referencing of the on-board timing function. Although the simulation program did not employ a full crew complement, the console operator did provide the time hacks that will normally come from the right-hand crewman. The apparent over-reliance on the event timer in the simulation may have resulted from lack of familiarity with general ascent procedures which will not be the case for actual flights.

Crew response to various tasks is determined by the severity of the task, physical ability of the crew, training, etc. This information is usually measured as crew performance and is evaluated by examination of the improvement in performance as a function of time. Initially, the crew is provided with a set of procedures and a task with the associated displays. The resulting performance over a certain time interval will produce two major areas of evaluation:

A. Simple and effective tasks with the associated procedures are identified and separated from the more difficult tasks.

B. The crew can, after experiencing the severity of the task, provide first hand inputs and recommendations as to the suitability of the procedures, displays, etc.

8.3 (Continued)

Any changes directed toward the crew station configuration should be a result of the experience gained by the crew in the process of abort detection and execution during training. It is important that generalized "improvement" changes emanating from other sources be withheld in order to maintain the integrity of the present simulation results.

Use of the RATE light as the primary cue for escape initiation requires that the crew watch the flight director needles in addition, in case the light fails to function. Since the crew cannot observe the normal operation of the light as an indication of operational status, both the light and the F.D.I.'s must be monitored and compared. This introduces a redundant complication to crew procedures which is undesirable.

Designation of the rate needles as the primary cue for escape initiation would permit the crew to verify normal operation of the display system up to the time of its use, thus eliminating the need for the dual monitoring.

9. CONCLUSIONS AND RECOMMENDATIONS

The basic response time characteristics, established under the primary objective of this program, have demonstrated the crew's capability to positively and accurately initiate abort/escape action under simulated Stage "0" abort conditions. Evaluation of these response characteristics against the current safe-escape requirements shows no justification for automating the escape functions.

The following comments outline the conclusions drawn from the evaluations developed in this report and recommend, where appropriate, those steps deemed necessary to minimize the Stage "0" crew risk.

Mode A Aborts - The present Gemini B crew station configuration and abort procedures permit the crew to initiate spacecraft escape and seat ejection well within the defined constraints. Addition of the EJECT light or other discrete timing cue is unwarranted by the performance data and current escape action window. Actual flight conditions that will provide the noise, vibration, and acceleration cues that were not available in the simulator should improve the crew's ability to approach the same timing consistency obtained using the EJECT light.

Mode B Aborts - The crew are able to perform the critical escape separation task with a high degree of assurance using the RATE light as the escape initiation cue. The currently implemented rate threshold (5.5 degrees/second) for RATE light activation requires the more difficult crew response and yields a lower probability of safe escape than can be achieved with a higher rate threshold. Use of the FDI rate needles as the primary escape initiation cue appears to be superior to the RATE light, however, insufficient data were recorded to firmly establish the crew response characteristics.

9. (Continued)

After completion of the next cycle of escape analyses based on updated launch vehicle motion tapes, a rate threshold for RATE light activation that optimizes safe escape probability for all malfunctions will be established. McDonnell recommends that the launch vehicle Malfunction Detection System be modified, at that time, to sense this threshold for the RATE light discrete.

It is further recommended that additional evaluation of the FDI utilization as the primary escape initiation cue be performed.

Abort Displays and Controls - The results of the simulation demonstrate the overall acceptability of the Gemini B displays and controls for meeting the informational and functional requirements of the crew during the Mode A and Mode B abort situations. Crew criticism of the displays during the test were, for the most part, related to features that are unique to the modified NASA gondola and the outdated tank pressure meter scales. Subsequent review shows that the current Gemini B crew station configuration satisfies these objectives. Detection of a single-bulb-out condition in the warning light modules on the Stage I pressure indicator and the TVC lights on the Stage "O" indicator can be improved by the addition of a separator between the bulbs. McDonnell recommends that this change be implemented. Use of the FDI rate needles for Mode B escape initiation timing prompted comment on the lack of contrast between needles and the desirability of adding a rate threshold index for reference. McDonnell defers a recommendation on these changes until the FDI is established as the primary reference for escape initiation.

10. REFERENCES

1. Schallenmuller, A. R., "Stage '0' Abort Decision Criteria," Martin Marietta Corporation Report MCR-67-339, September 1967.

2. Seeney, P. J., "Gemini B Data For The LTV Abort Engineering Simulation Program," McDonnell Astronautics Company Aerodynamic Technical Note Number 48, July 1967.

3. Sewell, H. E., Jr., "Gemini B Abort Engineering Simulation Requirements," LTV Aerospace Corporation Report LTV-MAFS-GAB-1, August 1967.

4. Seeney, P. J., "LTV Abort Engineering Simulations, Gemini B Escape Success Criteria, Data Analysis Technique, And Plan For Presentation Of Results," McDonnell Astronautics Company Aerodynamic Technical Note Number 52, October 1967.

5. McDonnell Astronautics Company Contract Change Proposal No. 51, "ICN 009 to IFS-MOL-201001".

APPENDIX

TABLE I

LIST OF SIMULATION CASES

CASE NO.	MALFUNCTION TYPE	MALF. START TIME	MODE A PACS SETTING	REMARKS
1	Ignition Failure SRM 1	0.	East	
2	Ignition Failure SRM 2	0.	West	
3	Ignition Failure SRM 1	0.	East	
4	Ignition Failure SRM 1	0.	East	
5	Ignition Failure SRM 1	0.	West	
6	Ignition Failure SRM 1	0.	West	
7	Ignition Failure SRM 1	0.	West	
8	Ignition Failure SRM 2	0.	East	
9	Ignition Failure SRM 2	0.	East	
10	Ignition Failure SRM 2	0.	East	
11	Ignition Failure SRM 2	0.	West	
12	Ignition Failure SRM 2	0.	West	
13	St. I Ox Tank Gas Leak	0.	East	
14	St. I Ox Tank Liq. Leak	4.	East	
15	St. II Fuel Liq. Leak	10.	West	
16	St. II Ox Tank Liq. Leak	20.	West	
17	TVC Null SRM 1	8.	East	
18	TVC Null SRM 2	12.	East	
19	TVC Null SRM 1	16.	West	
20	TVC Null SRM 2	20.	West	
21	Burnthrough Augment SRM 1	15.	East	
22	Burnthrough Augment SRM 2	18.	West	
23	Burnthrough Augment SRM 1	20.	West	
24	Burnthrough Augment SRM 2	22.	East	
25	Burnthrough Oppose SRM 2	18.	East	
26	Burnthrough Oppose SRM 2	20.	West	
27	Burnthrough Oppose SRM 1	20.	East	
28	Burnthrough Oppose SRM 1	22.	West	
29	St. I Ox Tank Gas Leak	20.	East	
30	St. I Ox Tank Liq. Leak	24.	West	
31	St. II Ox Tank Liq. Leak	35.	East	
32	St. II Fuel Liq. Leak	38.	West	

TABLE I (CONTINUED)

LIST OF SIMULATION CASES

CASE NO.	MALFUNCTION TYPE	MALF. START TIME	MODE A PACS SETTING	REMARKS
33	St. I Fuel Tank Gas Leak	50.	East	
34	St. II Ox Tank Gas Leak	52.	West	
35	St. II Fuel Liq. Leak	58.	East	
36	St. II Fuel Tank Gas Leak	61.	West	
37	St. I Fuel Liq. Leak	66.	East	
38	St. I Fuel Tank Gas Leak	66.	West	
39	Burnthrough Oppose SRM 1	27.	East	
40	Burnthrough Oppose SRM 2	30.	East	
41	Burnthrough Oppose SRM 1	35.	West	
42	Burnthrough Oppose SRM 2	40.	West	
43	Burnthrough Oppose SRM 1	47.	East	
44	Burnthrough Oppose SRM 2	54.	East	
45	Burnthrough Oppose SRM 1	60.	West	
46	Burnthrough Oppose SRM 2	64.	West	
47	Burnthrough Oppose SRM 1	66.	East	
48	Burnthrough Oppose SRM 2	69.	West	
49	Burnthrough Augment SRM 1	24.	East	
50	Burnthrough Augment SRM 2	28.	East	
51	Burnthrough Augment SRM 1	33.	West	
52	Burnthrough Augment SRM 2	37.	West	
53	Burnthrough Augment SRM 1	48.	East	
54	Burnthrough Augment SRM 2	51.	East	
55	Burnthrough Augment SRM 1	59.	West	
56	Burnthrough Augment SRM 2	62.	West	
57	Burnthrough Augment SRM 1	66.	East	
58	Burnthrough Augment SRM 2	69.	West	
59	TVC Null SRM 1	28.	West	
60	TVC Null SRM 2	33.	East	
61	TVC Null SRM 1	40.	West	
62	TVC Null SRM 2	43.	East	
63	TVC Null SRM 1	54.	West	
64	TVC Null SRM 2	58.	East	

TABLE I (CONTINUED)

LIST OF SIMULATION CASES

CASE NO.	MALFUNCTION TYPE	MALF. START TIME	MODE A PACS SETTING	REMARKS
65	TVC Null SRM 1	62.	West	
66	TVC Null SRM 2	65.	East	
67	TVC Null SRM 1	69.	West	
68	TVC Null SRM 2	72.	East	
69	TVC Null SRM 1	27.	West	Roll Lockout
70	TVC Null SRM 2	30.	East	Roll Lockout
71	TVC Null SRM 1	50.	West	Roll Lockout
72	TVC Null SRM 2	55.	East	Roll Lockout
73	TVC Null SRM 1	70.	West	Roll Lockout
74	TVC Null SRM 2	72.	East	Roll Lockout
75	Burnthrough Oppose SRM 1	51.	East	Roll Lockout
76	Burnthrough Oppose SRM 2	55.	West	Roll Lockout
77	Burnthrough Augment SRM 1	48.	West	Roll Lockout
78	Burnthrough Augment SRM 2	50.	East	Roll Lockout
79	St. I Fuel Tank Gas Leak	25.	West	No Abort
80	St. II Ox Tank Gas Leak	0.	East	No Abort
81	SRM Head End Debonds SRM 1	4.	East	No Abort
82	SRM Aft End Debonds SRM 2	48.	West	No Abort
83	St. I Fuel Tank Tr. 2 to 0 Press.	13.	East	No Abort
84	APS 1 Power Loss	35.	East	No Abort
85	TCPS 1 in SA-1 Fail Open	54.	East	No Abort
86	TVC Pr. Sw. 2 in SRM 2 Fails Open	68.	East	No Abort
87	Trans. 1 in SRM 1 to 0 Press.	76.	West	No Abort
88	TCPS 1 in SA-2 Fail Closed	90.	West	No Abort
89	St. I SA-2 Fail to Start	122.	West	
90	St. I SA-1 Fail to Start	122.	East	
91	Free Ride No Malfunction			
92	St. I Ox Tank Gas Leak	90.	West	No Abort
93	TCPS 2 in SA-1 Fail Closed	100.	East	No Abort
94	St. I Fuel Tank Tr. 1 to Full Output	20.	East	No Abort
95	APS 2 Power Loss	68.	East	No Abort
96	Trans. 2 in SRM 2 to Full Output	40.	East	No Abort
97	St. II Ox Tank Pr. Tr. 2 to 0 Press.	21.	East	No Abort

TABLE II

MODE A PAD ABORT DATA

CASE NO.	TIMES AFTER SRM IGNITION, SECONDS				RESPONSE TIME	CUE
	START OF MALFUNCTION	THRUST TERM. ABORT LIGHT	ESCAPE INITIATION	D-RING PULLED		
1	0	.2	2.22	8.71	6.49	No Eject Light
1	0	.2	2.41	8.52	6.11	
1	0	.2	1.16	7.68	6.52	
1	0	.2	1.06	7.63	6.57	
1	0	.2	1.76	8.18	6.42	
1	0	.2	1.94	8.24	6.30	
1	0	.2	1.20	7.49	6.29	With Eject Light
1	0	.2	1.49	7.83	6.34	
1	0	.2	1.04	7.36	6.32	
1	0	.2	1.05	7.34	6.29	
1	0	.2	1.81	8.21	6.40	
1	0	.2	1.62	7.92	6.30	
2	0	.2	1.41	8.02	6.61	No Eject Light
2	0	.2	2.48	8.82	6.34	
2	0	.2	1.20	7.55	6.35	
2	0	.2	1.20	7.69	6.49	
2	0	.2	1.92	8.38	6.46	
2	0	.2	2.08	8.43	6.35	
2	0	.2	1.22	7.50	6.28	With Eject Light
2	0	.2	1.96	8.34	6.38	
2	0	.2	1.15	7.48	6.33	
2	0	.2	1.15	7.43	6.28	
2	0	.2	1.63	8.00	6.37	
2	0	.2	1.64	7.91	6.27	
3	0	.2	1.36	7.88	6.52	No Eject Light
3	0	.2	2.36	8.68	6.32	
3	0	.2	1.00	7.45	6.46	
3	0	.2	1.02	7.53	6.51	
3	0	.2	2.00	8.54	6.54	
3	0	.2	1.77	8.10	6.33	
3	0	.2	1.13	7.45	6.32	With Eject Light
3	0	.2	2.00	8.29	6.29	
3	0	.2	1.00	7.29	6.29	
3	0	.2	1.02	7.33	6.31	
3	0	.2	1.41	7.78	6.37	
3	0	.2	1.53	7.85	6.32	

TABLE II (CONTINUED)

MODE A PAD ABORT DATA

CASE NO.	TIMES AFTER SRM IGNITION, SECONDS				RESPONSE TIME	CUE
	START OF MALFUNCTION	THRUST TERM. ABORT LIGHT	ESCAPE INITIATION	D-RING PULLED		
4	0	.2	1.36	7.83	6.47	No Eject Light
4	0	.2	2.87	9.23	6.36	
4	0	.2	1.23	7.67	6.44	
4	0	.2	1.08	7.42	6.34	
4	0	.2	1.86	8.41	6.55	
4	0	.2	1.99	8.31	6.32	
4	0	.2	1.30	7.54	6.24	With Eject Light
4	0	.2	1.69	8.25	6.56	
4	0	.2	1.06	7.37	6.31	
4	0	.2	1.13	7.49	6.36	
4	0	.2	1.63	7.97	6.34	
4	0	.2	1.48	7.79	6.31	
5	0	.2	1.45	7.89	6.44	No Eject Light
5	0	.2	2.24	8.45	6.21	
5	0	.2	1.24	7.64	6.40	
5	0	.2	1.22	7.62	6.40	
5	0	.2	1.84	8.33	6.49	
5	0	.2	1.94	8.20	6.26	
5	0	.2	1.38	7.67	6.29	With Eject Light
5	0	.2	2.30	8.69	6.39	
5	0	.2	1.34	7.62	6.28	
5	0	.2	1.18	7.54	6.36	
5	0	.2	1.52	7.87	6.35	
5	0	.2	1.58	7.92	6.34	
6	0	.2	1.28	7.80	6.52	No Eject Light
6	0	.2	2.51	8.83	6.32	
6	0	.2	1.37	7.97	6.60	
6	0	.2	1.16	7.64	6.48	
6	0	.2	1.83	8.33	6.50	
6	0	.2	1.82	8.21	6.39	
6	0	.2	1.18	7.46	6.28	With Eject Light
6	0	.2	2.16	8.50	6.34	
6	0	.2	1.21	7.54	6.33	
6	0	.2	1.04	7.34	6.30	
6	0	.2	1.39	7.74	6.35	
6	0	.2	1.43	7.74	6.31	

TABLE II (CONTINUED)

MODE A PAD ABORT DATA

CASE NO.	TIMES AFTER SRM IGNITION, SECONDS				RESPONSE TIME	CUE
	START OF MALFUNCTION	THRUST TERM. ABORT LIGHT	ESCAPE INITIATION	D-RING PULLED		
7	0	.2	1.37	7.89	6.52	No Eject Light
7	0	.2	2.33	8.50	6.17	
7	0	.2	1.25	7.74	6.49	
7	0	.2	1.12	7.59	6.47	
7	0	.2	1.99	8.48	6.49	
7	0	.2	1.80	8.28	6.48	
7	0	.2	1.21	7.52	6.31	With Eject Light
7	0	.2	1.61	7.96	6.35	
7	0	.2	1.20	7.54	6.34	
7	0	.2	1.07	7.40	6.33	
7	0	.2	1.84	8.21	6.37	
7	0	.2	1.57	7.89	6.32	
8	0	.2	1.89	8.17	6.28	No Eject Light
8	0	.2	2.37	8.37	6.00	
8	0	.2	1.56	7.93	6.37	
8	0	.2	.90	7.29	6.39	
8	0	.2	1.77	8.16	6.39	
8	0	.2	1.64	8.06	6.42	
8	0	.2	1.54	7.81	6.27	With Eject Light
8	0	.2	1.99	8.56	6.57	
8	0	.2	1.08	7.45	6.37	
8	0	.2	1.13	7.50	6.37	
8	0	.2	1.66	8.15	6.49	
8	0	.2	1.44	7.73	6.29	
9	0	.2	1.57	8.04	6.47	No Eject Light
9	0	.2	2.13	8.43	6.30	
9	0	.2	1.18	7.66	6.48	
9	0	.2	1.07	7.53	6.46	
9	0	.2	1.89	8.43	6.54	
9	0	.2	1.92	8.30	6.38	
9	0	.2	1.16	7.47	6.31	With Eject Light
9	0	.2	1.70	7.98	6.28	
9	0	.2	1.35	7.68	6.33	
9	0	.2	1.09	7.46	6.37	
9	0	.2	1.39	7.71	6.32	
9	0	.2	1.41	7.76	6.35	

TABLE II (CONTINUED)

MODE A PAD ABORT DATA

CASE NO.	TIMES AFTER SRM IGNITION, SECONDS: START OF MALFUNCTION	THRUST TERM. ABORT LIGHT	ESCAPE INITIATION	D-RING PULLED	RESPONSE TIME	CUE
10	0	.2	1.48	7.87	6.39	No Eject Light
10	0	.2	3.21	9.51	6.30	
10	0	.2	1.09	7.55	6.46	
10	0	.2	1.02	7.51	6.49	
10	0	.2	1.83	8.37	6.54	
10	0	.2	1.95	8.24	6.29	
10	0	.2	1.26	7.60	6.34	With Eject Light
10	0	.2	1.73	8.06	6.33	
10	0	.2	.96	7.29	6.33	
10	0	.2	1.02	7.41	6.39	
10	0	.2	1.73	8.18	6.45	
10	0	.2	1.79	8.16	6.37	
11	0	.2	1.47	7.92	6.45	No Eject Light
11	0	.2	2.33	8.45	6.12	
11	0	.2	1.07	7.46	6.39	
11	0	.2	1.16	7.56	6.40	
11	0	.2	1.78	8.36	6.58	
11	0	.2	1.86	8.19	6.33	
11	0	.2	1.15	7.45	6.30	With Eject Light
11	0	.2	2.21	8.56	6.35	
11	0	.2	1.17	7.60	6.43	
11	0	.2	1.04	7.38	6.34	
11	0	.2	1.43	7.83	6.40	
11	0	.2	1.59	7.94	6.35	
12	0	.2	1.88	8.29	6.41	No Eject Light
12	0	.2	2.44	8.81	6.37	
12	0	.2	1.25	7.64	6.39	
12	0	.2	1.28	7.77	6.49	
12	0	.2	1.84	8.34	6.50	
12	0	.2	1.73	8.12	6.39	
12	0	.2	1.24	7.55	6.31	With Eject Light
12	0	.2	1.52	7.90	6.38	
12	0	.2	1.13	7.43	6.30	
12	0	.2	1.01	7.37	6.36	
12	0	.2	1.92	8.31	6.39	
12	0	.2	1.57	7.89	6.32	

TABLE III

MODE A IN-FLIGHT DATA

CASE NO.	TIMES AFTER SRM IGNITION, SECONDS: START OF MALFUNCTION	THRUST TERM. ABORT LIGHT	ESCAPE INITIATION	D-RING PULLED	RESPONSE TIME	CUE
13	0	5.40	6.41	12.61	6.20	No Eject Light
13	0	5.10	6.20	12.68	6.48	
13	0	4.00	4.74	11.04	6.30	
13	0	6.80	7.21	13.59	6.38	
13	0	4.80	6.38	12.82	6.44	
13	0	6.25	7.33	13.85	6.52	
13	0	5.50	6.53	12.85	6.32	With Eject Light
13	0	5.15	6.18	12.49	6.31	
13	0	5.20	5.99	12.29	6.30	
13	0	5.30	5.90	12.22	6.32	
13	0	6.10	7.70	14.10	6.40	
13	0	6.00	6.90	13.14	6.24	
14	4	7.15	7.88	14.45	6.57	No Eject Light
14	4	7.15	8.41	14.78	6.37	
14	4	7.00	7.88	14.28	6.40	
14	4	7.65	8.16	14.61	6.45	
14	4	6.80	7.92	14.44	6.52	
14	4	7.70	8.49	14.96	6.47	
14	4	7.25	7.98	14.27	6.29	With Eject Light
14	4	6.60	7.76	14.25	6.49	
14	4	6.40	7.32	13.63	6.31	
14	4	7.25	7.83	14.14	6.31	
14	4	7.65	8.24	14.66	6.42	
14	4	6.80	7.64	13.89	6.25	
15	10	12.30	13.22	19.56	6.34	No Eject Light
15	10	12.55	13.69	20.31	6.62	
15	10	11.70	12.16	18.62	6.46	
15	10	12.40	12.86	19.27	6.41	
15	10	11.40	12.65	19.22	6.57	
15	10	12.05	12.84	19.57	6.73	
15	10	12.35	13.06	19.35	6.29	With Eject Light
15	10	12.40	13.39	19.73	6.34	
15	10	11.65	12.60	18.88	6.28	
15	10	12.05	12.78	19.12	6.34	
15	10	12.00	12.83	19.22	6.39	
15	10	12.10	12.87	19.21	6.34	

TABLE III (CONTINUED)

MODE A IN-FLIGHT DATA

CASE NO.	TIMES AFTER SRM IGNITION, SECONDS: START OF MALFUNCTION	THRUST TERM. ABORT LIGHT	ESCAPE INITIATION	D-RING PULLED	RESPONSE TIME	CUE
16	20	21.90	23.16	29.84	6.68	No Eject Light
16	20	21.85	22.88	29.37	6.49	
16	20	21.65	22.07	28.64	6.57	
16	20	21.85	22.52	29.13	6.61	
16	20	21.80	22.49	29.23	6.74	
16	20	21.65	22.57	29.06	6.49	
16	20	21.95	23.08	29.39	6.31	With Eject Light
16	20	21.50	22.33	28.67	6.34	
16	20	21.70	22.87	29.20	6.33	
16	20	21.75	22.72	29.08	6.36	
16	20	21.55	23.05	29.42	6.37	
16	20	21.55	22.29	28.57	6.28	
17	8	8.05	9.65	16.21	6.56	No Eject Light
17	8	8.05	10.12	16.48	6.36	
17	8	8.08	9.34	15.75	6.41	
17	8	8.05	9.13	15.63	6.50	
17	8	8.05	9.53	16.03	6.50	
17	8	8.05	9.56	15.98	6.42	
17	8	8.05	9.74	16.04	6.30	With Eject Light
17	8	8.05	9.75	16.07	6.32	
17	8	8.05	9.47	15.76	6.29	
17	8	8.05	9.16	15.53	6.37	
17	8	8.05	9.38	15.80	6.42	
17	8	8.05	9.49	15.76	6.27	
18	12	12.05	13.47	20.08	6.61	No Eject Light
18	12	12.05	13.49	19.67	6.18	
18	12	12.05	13.34	20.21	6.87	
18	12	12.05	13.18	19.83	6.65	
18	12	12.05	14.08	20.45	6.37	
18	12	12.05	13.84	20.21	6.37	
18	12	12.05	13.43	19.71	6.28	With Eject Light
18	12	12.05	13.57	20.10	6.53	
18	12	12.05	13.53	19.83	6.30	
18	12	12.05	13.02	19.35	6.33	
18	12	12.05	13.54	19.86	6.32	
18	12	12.05	13.55	19.81	6.26	

TABLE III (CONTINUED)

MODE A IN-FLIGHT DATA

CASE NO.	TIMES AFTER SRM IGNITION, SECONDS: START OF MALFUNCTION	THRUST TERM. ABORT LIGHT	ESCAPE INITIATION	D-RING PULLED	RESPONSE TIME	CUE
19	16	16.05	17.81	24.42	6.61	No Eject Light
19	16	16.05	18.10	24.20	6.10	
19	16	16.05	17.36	23.92	6.56	
19	16	16.05	17.73	24.37	6.64	
19	16	16.05	17.60	23.93	6.33	
19	16	16.05	17.41	23.82	6.41	
19	16	16.05	17.99	24.28	6.29	With Eject Light
19	16	16.05	17.73	24.04	6.31	
19	16	16.05	17.55	23.83	6.28	
19	16	16.05	17.21	23.54	6.33	
19	16	16.05	17.45	23.89	6.44	
19	16	16.05	17.28	23.55	6.27	
20	20	20.05	21.49	27.87	6.38	No Eject Light
20	20	20.05	21.73	28.27	6.54	
20	20	20.05	21.56	28.08	6.52	
20	20	20.05	21.72	28.03	6.31	
20	20	20.05	21.84	28.47	6.63	
20	20	20.05	21.65	28.09	6.44	
20	20	20.05	21.19	27.47	6.28	With Eject Light
20	20	20.05	21.38	27.73	6.35	
20	20	20.05	21.65	27.95	6.30	
20	20	20.05	21.89	28.21	6.32	
20	20	20.05	21.31	27.72	6.41	
20	20	20.05	21.35	27.63	6.28	
21	15	18.05	18.91	25.46	6.55	No Eject Light
21	15	18.05	19.82	26.65	6.83	
21	15	18.05	18.88	25.38	6.50	
21	15	18.05	18.96	25.43	6.47	
21	15	18.05	19.65	26.03	6.38	
21	15	18.05	19.97	26.32	6.35	
21	15	18.05	19.27	25.57	6.30	With Eject Light
21	15	18.05	19.18	25.54	6.36	
21	15	18.05	18.85	24.14	6.29	
21	15	18.05	18.84	25.13	6.29	
21	15	18.05	19.19	25.58	6.39	
21	15	18.05	18.98	25.32	6.34	

TABLE III (CONTINUED)

MODE A IN-FLIGHT DATA

CASE NO.	TIMES AFTER SRM IGNITION, SECONDS START OF MALFUNCTION	THRUST TERM. ABORT LIGHT	ESCAPE INITIATION	D-RING PULLED	RESPONSE TIME	CUE
22	18	21.05	22.46	28.98	6.52	No Eject Light
22	18	21.05	22.47	28.77	6.30	
22	18	21.05	21.89	28.40	6.51	
22	18	21.05	22.71	29.26	6.55	
22	18	21.05	22.23	28.78	6.55	
22	18	21.05	22.19	28.56	6.37	
22	18	21.05	22.42	28.72	6.30	With Eject Light
22	18	21.05	22.14	28.53	6.39	
22	18	21.05	23.09	29.41	6.32	
22	18	21.05	22.34	28.90	6.56	
22	18	21.05	21.96	28.30	6.34	
22	18	21.05	22.08	28.50	6.42	
23	20	23.05	24.79	31.37	6.58	No Eject Light
23	20	23.05	24.52	30.95	6.43	
23	20	23.05	24.48	31.06	6.58	
23	20	23.05	24.14	30.46	6.32	
23	20	23.05	24.58	30.91	6.33	
23	20	23.05	24.45	30.93	6.48	
23	20	23.05	24.44	30.74	6.30	With Eject Light
23	20	23.05	24.21	30.69	6.48	
23	20	23.05	24.03	30.34	6.31	
23	20	23.05	24.38	30.77	6.39	
23	20	23.05	24.25	30.64	6.39	
23	20	23.05	23.93	30.26	6.33	
24	22	25.05	27.06	33.66	6.60	No Eject Light
24	22	25.05	27.17	33.45	6.28	
24	22	24.95	25.50	32.10	6.60	
24	22	25.05	26.21	32.90	6.69	
24	22	25.05	26.33	32.87	6.54	
24	22	25.05	26.33	33.04	6.71	
24	22	25.05	26.90	33.19	6.29	With Eject Light
24	22	25.05	26.33	32.64	6.31	
24	22	25.05	26.12	32.45	6.33	
24	22	25.05	26.98	33.39	6.41	
24	22	25.05	26.59	33.05	6.46	
24	22	25.05	26.01	32.33	6.32	

TABLE III (CONTINUED)

MODE A IN-FLIGHT DATA

CASE NO.	TIMES AFTER SRM IGNITION, SECONDS				RESPONSE TIME	CUE
	START OF MALFUNCTION	THRUST TERM. ABORT LIGHT	ESCAPE INITIATION	D-RING PULLED		
25	18	21.05	22.49	29.14	6.65	No Eject Light
25	18	21.05	22.42	28.62	6.20	
25	18	21.05	21.89	28.59	6.70	
25	18	21.05	22.38	28.99	6.61	
25	18	21.05	22.12	28.71	6.59	
25	18	21.05	22.28	28.72	6.44	
25	18	21.05	22.02	28.34	6.32	With Eject Light
25	18	21.05	22.19	28.60	6.41	
25	18	21.05	22.29	28.62	6.33	
25	18	21.05	22.10	28.40	6.30	
25	18	21.05	22.32	28.68	6.36	
25	18	21.05	22.01	28.37	6.36	
26	20	23.05	24.90	31.49	6.59	No Eject Light
26	20	23.05	24.79	31.11	6.32	
26	20	23.05	25.20	31.85	6.65	
26	20	23.05	23.94	30.44	6.50	
26	20	23.05	24.56	31.04	6.48	
26	20	23.05	24.22	30.67	6.45	
26	20	23.05	24.46	30.78	6.32	With Eject Light
26	20	23.05	23.93	30.29	6.36	
26	20	23.00	24.55	30.88	6.33	
26	20	23.05	24.01	30.35	6.34	
26	20	23.05	24.35	30.67	6.32	
26	20	23.05	24.32	30.69	6.37	
27	20	23.05	24.40	30.88	6.48	No Eject Light
27	20	23.05	24.59	31.36	6.67	
27	20	23.05	24.11	30.64	6.53	
27	20	23.05	24.20	30.50	6.30	
27	20	23.05	24.17	30.97	6.80	
27	20	23.05	23.98	30.27	6.39	
27	20	23.05	24.62	30.95	6.33	With Eject Light
27	20	23.05	24.24	30.62	6.38	
27	20	23.05	24.33	30.72	6.39	
27	20	23.05	23.94	30.22	6.28	
27	20	23.05	24.64	31.04	6.40	
27	20	23.05	24.10	30.36	6.26	

TABLE III (CONTINUED)

MODE A IN-FLIGHT DATA

CASE NO.	TIMES AFTER SRM IGNITION, SECONDS				RESPONSE TIME	CUE
	START OF MALFUNCTION	THRUST TERM. ABORT LIGHT	ESCAPE INITIATION	D-RING PULLED		
28	22	25.05	26.85	33.47	6.62	No Eject Light
28	22	25.05	26.79	32.87	6.08	
28	22	25.05	26.10	32.64	6.54	
28	22	25.05	26.97	34.16	7.19	
28	22	25.05	26.24	32.64	6.40	
28	22	25.05	26.85	33.16	6.31	
28	22	25.05	26.64	32.91	6.27	With Eject Light
28	22	25.05	26.18	32.55	6.37	
28	22	25.05	26.49	32.81	6.32	
28	22	25.05	25.97	32.26	6.29	
28	22	25.05	26.25	32.70	6.45	
28	22	25.05	26.85	33.26	6.41	

TABLE IV

MODE B STRAIGHT-AHEAD FAILURE DATA

CASE NO.	TIMES AFTER SRM IGNITION, SECONDS				RESPONSE TIME	CUE
	START OF MALFUNCTION	THRUST TERM. ABORT LIGHT	RATE LIGHT	ESCAPE INITIATION		
29	20	28.45	29.05	29.51	.46	5.5 deg/sec Rate Light FDI Low Setting
29	20	28.90	29.45	29.82	.37	
29	20	28.05	28.60	28.99	.39	
29	20	28.75	29.30	28.91	-.39	
29	20	29.10	29.65	30.31	.66	
29	20	29.20	29.75	30.41	.66	
29	20	28.65	29.50	29.81	.31	8.0 deg/sec Rate Light FDI Low Setting
29	20	29.55	30.35	30.40	.05	
29	20	28.75	29.55	29.88	.33	
29	20	29.55	30.40	30.69	.29	
29	20	26.90	27.95	27.95	.02	
29	20	28.30	29.15	29.53	.38	
30	24	28.80	29.35	29.75	.40	5.5 deg/sec Rate Light FDI Low Setting
30	24	29.65	30.20	30.61	.41	
30	24	26.20	27.70	28.07	.37	
30	24	27.60	28.10	28.52	.42	
30	24	27.85	28.40	28.86	.46	
30	24	28.15	28.70	29.23	.53	
30	24	29.35	30.15	30.43	.28	8.0 deg/sec Rate Light FDI Low Setting
30	24	30.05	30.85	31.16	.31	
30	24	28.70	29.55	29.92	.37	
30	24	27.70	28.55	28.88	.33	
30	24	30.70	31.50	31.84	.34	
30	24	28.35	29.20	29.58	.38	
30	24	29.65	30.45	30.81	.36	8.0 deg/sec Rate Light FDI High Setting
30	24	28.10	28.95	29.38	.43	
30	24	27.95	28.80	28.91	.11	
30	24	29.30	30.10	30.48	.38	
30	24	29.15	29.90	30.25	.35	8.0 deg/sec No Rate Light FDI High Setting
30	24	27.85	28.70	28.97	.27	
30	24	28.00	28.85	28.95	.10	
30	24	28.15	29.00	29.24	.24	

TABLE IV (CONTINUED)

MODE B STRAIGHT-AHEAD FAILURE DATA

CASE NO.	TIMES AFTER SRM IGNITION, SECONDS				RESPONSE TIME	CUE
	START OF MALFUNCTION	THRUST TERM. ABORT LIGHT	RATE LIGHT	ESCAPE INITIATION		
31	35	37.70	38.25	38.65	.40	5.5 deg/sec
31	35	37.80	38.35	38.70	.35	Rate Light
31	35	36.55	37.10	36.99	-.11	FDI Low Setting
31	35	36.50	37.05	37.34	.29	
31	35	36.35	36.90	37.21	.31	
31	35	36.80	37.35	37.75	.40	
31	35	37.85	38.60	38.94	.34	8.0 deg/sec
31	35	37.65	38.40	38.84	.44	Rate Light
31	35	36.60	37.40	37.80	.40	FDI Low Setting
31	35	37.10	37.90	38.21	.31	
31	35	37.15	37.90	38.20	.30	
31	35	36.75	37.55	37.87	.32	
32	38	42.05	42.55	42.91	.36	5.5 deg/sec
32	38	41.90	42.40	42.75	.35	Rate Light
32	38	39.55	40.05	40.41	.36	FDI Low Setting
32	38	40.70	41.20	41.55	.35	
32	38	40.85	41.35	41.86	.51	
32	38	40.84	41.30	41.81	.51	
32	38	42.00	42.75	43.05	.30	8.0 deg/sec
32	38	41.70	42.45	42.70	.25	Rate Light
32	38	40.20	40.95	41.28	.33	FDI Low Setting
32	38	40.20	40.95	41.27	.32	
32	38	40.55	41.30	41.60	.30	
32	38	40.50	41.25	41.56	.31	
32	38	42.05	42.80	43.14	.34	8.0 deg/sec
32	38	39.80	40.55	40.77	.22	Rate Light
32	38	41.10	41.85	42.12	.27	FDI High Setting
32	38	40.70	41.45	41.76	.31	
32	38	41.60	42.35	42.69	.34	8.0 deg/sec
32	38	40.70	41.45	41.72	.27	No Rate Light
32	38	40.35	41.10	41.40	.30	FDI High Setting
32	38	41.50	42.25	42.72	.47	

TABLE IV (CONTINUED)

MODE B STRAIGHT-AHEAD FAILURE DATA

CASE NO.	TIMES AFTER SRM IGNITION, SECONDS				RESPONSE TIME	CUE
	START OF MALFUNCTION	THRUST TERM. ABORT LIGHT	RATE LIGHT	ESCAPE INITIATION		
33	50	52.70	53.15	53.52	.37	5.5 deg/sec
33	50	53.45	53.90	54.41	.51	Rate Light
33	50	52.00	52.50	52.82	.32	FDI Low Setting
33	50	52.65	53.10	53.40	.30	
33	50	51.75	52.25	52.83	.58	
33	50	52.55	53.00	53.49	.49	
33	50	53.05	53.75	54.05	.30	8.0 deg/sec
33	50	53.20	53.90	54.24	.34	Rate Light
33	50	51.40	52.10	52.44	.34	FDI Low Setting
33	50	53.00	53.70	54.02	.32	
33	50	53.30	54.00	54.31	.31	
33	50	52.40	53.10	53.41	.31	
34	52	55.25	55.70	56.15	.45	5.5 deg/sec
34	52	55.20	55.65	56.07	.42	Rate Light
34	52	53.75	54.20	55.75	1.55*	FDI Low Setting
34	52	54.90	55.35	55.72	.37	
34	52	53.30	53.75	54.29	.54	
34	52	54.50	54.95	55.37	.42	
34	52	55.35	56.00	56.30	.30	8.0 deg/sec
34	52	55.55	56.20	56.53	.33	Rate Light
34	52	53.65	54.35	54.69	.34	FDI Low Setting
34	52	54.80	55.50	55.80	.30	
34	52	54.60	55.30	55.60	.30	
34	52	53.95	54.60	54.92	.32	
34	52	55.40	56.05	56.38	.33	8.0 deg/sec
34	52	54.10	54.80	55.00	.20	Rate Light
34	52	55.40	56.05	56.38	.33	FDI High Setting
34	52	54.95	55.60	55.80	.20	
34	52	55.43	56.08	56.33	.25	8.0 deg/sec
34	52	53.95	54.65	54.86	.21	No Rate Light
34	52	54.25	54.95	55.19	.24	FDI High Setting
34	52	54.55	55.25	55.39	.14	

* Mechanical trouble with abort handle. Data point invalid.

TABLE IV (CONTINUED)

MODE B STRAIGHT-AHEAD FAILURE DATA

CASE NO.	TIMES AFTER SRM IGNITION, SECONDS START OF MALFUNCTION	THRUST TERM. ABORT LIGHT	RATE LIGHT	ESCAPE INITIATION	RESPONSE TIME	CUE
35	58	63.10	63.50	63.90	.40	5.5 deg/sec
35	58	60.20	60.70	61.45	.75	Rate Light
35	58	59.65	60.40	60.73	.33	FDI Low Setting
35	58	60.90	61.35	61.67	.32	
35	58	59.90	60.35	60.88	.53	
35	58	60.50	60.95	61.47	.52	
35	58	64.75	65.39	65.63	.24	8.0 deg/sec
35	58	63.60	64.20	64.58	.38	Rate Light
35	58	60.00	60.65	60.97	.32	FDI Low Setting
35	58	61.55	62.20	62.49	.29	
35	58	62.25	63.25	63.72	.47	
35	58	59.70	60.35	60.67	.32	
36	61	63.15	63.55	63.92	.37	5.5 deg/sec
36	61	62.90	63.35	63.70	.35	Rate Light
36	61	62.20	62.65	63.01	.36	FDI Low Setting
36	61	62.45	62.90	63.23	.33	
36	61	62.25	62.70	62.98	.28	
36	61	62.65	63.10	63.46	.36	
36	61	63.15	63.75	64.02	.27	8.0 deg/sec
36	61	63.25	63.85	64.18	.33	Rate Light
36	61	62.35	63.00	63.17	.17	FDI Low Setting
36	61	62.75	63.45	63.69	.24	
36	61	62.80	63.45	63.75	.30	
36	61	62.35	63.00	63.40	.40	
37	66	72.00	72.40	72.81	.41	5.5 deg/sec
37	66	72.95	73.35	73.90	.55	Rate Light
37	66	67.60	68.00	68.39	.39	FDI Low Setting
37	66	69.15	69.55	69.97	.42	
37	66	68.50	68.90	69.33	.43	
37	66	69.65	70.05	70.64	.59	
37	66	72.70	73.30	73.59	.29	8.0 deg/sec
37	66	72.30	72.90	73.25	.35	Rate Light
37	66	67.35	67.95	68.12	.17	FDI Low Setting
37	66	72.60	73.20	73.54	.34	
37	66	69.65	70.25	70.61	.36	
37	66	68.95	69.55	69.93	.38	

TABLE IV (CONTINUED)

MODE B STRAIGHT-AHEAD FAILURE DATA

CASE NO.	TIMES AFTER SRM IGNITION, SECONDS				RESPONSE TIME	CUE
	START OF MALFUNCTION	THRUST TERM. ABORT LIGHT	RATE LIGHT	ESCAPE INITIATION		
38	66	70.65	71.05	71.55	.50	5.5 deg/sec
38	66	70.50	70.90	71.25	.35	Rate Light
38	66	67.60	68.00	68.45	.45	FDI Low Setting
38	66	68.80	69.20	69.54	.34	
38	66	68.90	69.30	69.75	.45	
38	66	68.70	69.10	69.47	.37	
38	66	70.50	71.10	71.33	.23	8.0 deg/sec
38	66	70.20	70.80	71.09	.29	Rate Light
38	66	67.95	68.55	69.02	.47	FDI Low Setting
38	66	69.70	70.30	70.60	.30	
38	66	70.05	70.65	71.08	.43	
38	66	68.90	69.50	69.87	.37	
38	66	70.30	70.90	71.31	.41	8.0 deg/sec
38	66	69.35	69.95	70.32	.37	Rate Light
38	66	69.50	70.10	70.34	.24	FDI High Setting
38	66	69.10	69.70	69.91	.21	
38	66	70.80	71.40	71.65	.25	8.0 deg/sec
38	66	69.15	69.75	70.03	.28	No Rate Light
38	66	69.65	70.25	70.56	.31	FDI High Setting
38	66	70.00	70.60	70.95	.35	

TABLE V

MODE B SRM CASE BURNTHROUGH (OPPOSED) FAILURE DATA

CASE NO.	TIMES AFTER SRM IGNITION, SECONDS START OF MALFUNCTION	THRUST TERM. ABORT LIGHT	RATE LIGHT	ESCAPE INITIATION	RESPONSE TIME	CUE
39	27	30.05	31.00	31.42	.42	5.5 deg/sec
39	27	30.05	31.05	31.38	.33	Rate Light
39	27	30.05	31.00	31.34	.34	FDI Low Setting
39	27	30.05	31.00	31.40	.40	
39	27	30.05	31.00	31.51	.51	
39	27	30.05	31.00	31.41	.41	
39	27	30.05	31.40	31.82	.42	8.0 deg/sec
39	27	30.05	31.40	31.73	.33	Rate Light
39	27	30.05	31.40	31.72	.32	FDI Low Setting
39	27	30.05	31.40	31.81	.41	
39	27	30.05	31.40	31.70	.30	
39	27	30.05	31.40	31.74	.34	
39	27	30.05	31.40	31.59	.19	8.0 deg/sec
39	27	30.05	31.40	31.84	.44	Rate Light
39	27	30.05	31.40	31.81	.41	FDI High Setting
39	27	30.05	31.40	31.81	.41	
39	27	30.05	31.40	31.64	.24	8.0 deg/sec
39	27	30.05	31.40	31.73	.33	No Rate Light
39	27	30.05	31.40	31.62	.22	FDI High Setting
39	27	30.05	31.40	31.74	.34	
40	30	33.05	34.00	34.51	.51	5.5 deg/sec
40	30	33.05	34.05	34.58	.53	Rate Light
40	30	33.05	34.00	34.51	.51	FDI Low Setting
40	30	33.05	34.00	34.42	.42	
40	30	33.05	34.00	34.55	.55	
40	30	33.05	34.00	34.47	.47	
40	30	33.05	34.35	34.64	.29	8.0 deg/sec
40	30	33.05	34.35	34.66	.31	Rate Light
40	30	33.05	34.35	34.73	.38	FDI Low Setting
40	30	33.05	34.35	34.68	.33	
40	30	33.05	34.35	34.65	.30	
40	30	33.05	34.35	34.67	.32	

TABLE V (CONTINUED)

MODE B SRM CASE BURNTHROUGH (OPPOSED) FAILURE DATA

CASE NO.	TIMES AFTER SRM IGNITION, SECONDS: START OF MALFUNCTION	THRUST TERM. ABORT LIGHT	RATE LIGHT	ESCAPE INITIATION	RESPONSE TIME	CUE
41	35	38.05	38.95	39.46	.51	5.5 deg/sec
41	35	38.05	38.95	39.38	.43	Rate Light
41	35	38.05	38.95	39.43	.48	FDI Low Setting
41	35	38.05	38.95	39.31	.36	
41	35	38.05	38.95	39.41	.46	
41	35	38.05	38.95	39.43	.48	
41	35	38.05	39.30	39.58	.28	8.0 deg/sec
41	35	38.05	39.30	39.62	.32	Rate Light
41	35	38.05	39.30	39.66	.36	FDI Low Setting
41	35	38.05	39.30	39.64	.34	
41	35	38.05	39.30	39.60	.30	
41	35	38.05	39.30	39.65	.35	
42	40	43.05	43.90	44.31	.41	5.5 deg/sec
42	40	43.05	43.90	44.39	.49	Rate Light
42	40	43.05	43.90	44.28	.38	FDI Low Setting
42	40	43.05	43.90	44.31	.41	
42	40	43.05	43.90	44.49	.59	
42	40	43.05	43.90	44.35	.45	
42	40	43.05	44.20	44.50	.30	8.0 deg/sec
42	40	43.05	44.20	44.52	.32	Rate Light
42	40	43.05	44.20	44.51	.31	FDI Low Setting
42	40	43.05	44.20	44.49	.29	
42	40	43.05	44.20	44.52	.32	
42	40	43.05	44.20	44.52	.32	
42	40	43.05	44.20	44.57	.37	8.0 deg/sec
42	40	43.05	44.20	44.56	.36	Rate Light
42	40	43.05	44.20	44.50	.30	FDI High Setting
42	40	43.05	44.30	44.65	.35	
42	40	43.05	44.20	44.53	.33	8.0 deg/sec
42	40	43.05	44.20	44.67	.47	No Rate Light
42	40	43.05	44.20	44.55	.35	FDI High Setting
42	40	43.05	44.20	44.54	.34	

TABLE V (CONTINUED)

MODE B SRM CASE BURNTHROUGH (OPPOSED) FAILURE DATA

CASE NO.	TIMES AFTER SRM IGNITION, SECONDS				RESPONSE TIME	CUE
	START OF MALFUNCTION	THRUST TERM. ABORT LIGHT	RATE LIGHT	ESCAPE INITIATION		
43	47	50.05	50.90	51.34	.44	5.5 deg/sec
43	47	50.05	50.90	51.32	.42	Rate Light
43	47	50.05	50.90	51.31	.41	FDI Low Setting
43	47	50.05	50.90	51.31	.41	
43	47	50.05	50.90	51.42	.52	
43	47	50.05	50.90	51.32	.42	
43	47	50.05	51.20	51.49	.29	8.0 deg/sec
43	47	50.05	51.20	51.52	.32	Rate Light
43	47	50.05	51.20	51.56	.36	FDI Low Setting
43	47	50.05	51.20	51.50	.30	
43	47	50.05	51.20	51.51	.31	
43	47	50.05	51.20	51.54	.34	
44	54	57.05	57.85	58.26	.41	5.5 deg/sec
44	54	57.05	57.85	58.48	.63	Rate Light
44	54	57.05	57.85	58.31	.46	FDI Low Setting
44	54	57.05	57.85	58.27	.42	
44	54	57.05	57.85	58.32	.47	
44	54	57.05	57.85	58.28	.43	
44	54	57.05	58.10	58.38	.28	8.0 deg/sec
44	54	57.05	58.10	58.42	.32	Rate Light
44	54	57.05	58.10	58.17	.07	FDI Low Setting
44	54	57.05	58.10	58.51	.41	
44	54	57.05	58.10	58.55	.45	
44	54	57.05	58.10	58.42	.32	
44	54	57.05	58.10	58.47	.37	8.0 deg/sec
44	54	57.05	58.10	58.50	.40	Rate Light
44	54	57.05	58.10	58.50	.40	FDI High Setting
44	54	57.05	58.10	58.48	.38	
44	54	57.05	58.10	58.36	.26	8.0 deg/sec
44	54	57.05	58.10	58.41	.31	No Rate Light
44	54	57.05	58.10	58.53	.43	FDI High Setting
44	54	57.05	58.10	58.47	.37	

TABLE V (CONTINUED)

MODE B SRM CASE BURNTHROUGH (OPPOSED) FAILURE DATA

CASE NO.	TIMES AFTER SRM IGNITION, SECONDS: START OF MALFUNCTION	THRUST TERM. ABORT LIGHT	RATE LIGHT	ESCAPE INITIATION	RESPONSE TIME	CUE
45	60	63.05	63.80	64.20	.40	5.5 deg/sec
45	60	63.05	63.80	64.19	.39	Rate Light
45	60	63.05	63.80	64.13	.33	FDI Low Setting
45	60	63.05	63.80	64.20	.40	
45	60	63.05	63.80	64.27	.47	
45	60	63.05	63.80	64.21	.41	
45	60	63.05	64.10	64.42	.32	8.0 deg/sec
45	60	63.05	64.10	64.42	.32	Rate Light
45	60	63.05	64.10	64.42	.32	FDI Low Setting
45	60	63.05	64.10	64.53	.43	
45	60	63.05	64.10	64.41	.31	
45	60	63.05	64.10	64.48	.38	
46	64	67.05	67.75	68.17	.42	5.5 deg/sec
46	64	67.05	67.75	68.25	.50	Rate Light
46	64	67.05	67.75	68.20	.45	FDI Low Setting
46	64	67.05	67.75	68.24	.49	
46	64	67.05	67.75	68.24	.49	
46	64	67.05	67.75	68.44	.69	
46	64	67.05	68.00	68.28	.28	8.0 deg/sec
46	64	67.05	68.00	68.34	.34	Rate Light
46	64	67.05	68.00	68.32	.32	FDI Low Setting
46	64	67.05	68.00	68.32	.32	
46	64	67.05	68.00	68.39	.39	
46	64	67.05	68.00	68.32	.32	
47	66	69.05	69.75	70.15	.40	5.5 deg/sec
47	66	69.05	69.75	70.14	.39	Rate Light
47	66	69.05	69.75	70.19	.44	FDI Low Setting
47	66	69.05	69.75	70.34	.59	
47	66	69.05	69.75	70.20	.45	
47	66	69.05	69.75	70.22	.47	
47	66	69.05	70.05	70.34	.29	8.0 deg/sec
47	66	69.03	69.98	70.28	.30	Rate Light
47	66	69.05	70.05	70.37	.32	FDI Low Setting
47	66	69.05	70.05	70.36	.31	
47	66	69.05	70.05	70.41	.36	
47	66	69.05	70.05	70.41	.36	

TABLE V (CONTINUED)

MODE B SRM CASE BURNTHROUGH (OPPOSED) FAILURE DATA

CASE NO.	TIMES AFTER SRM IGNITION, SECONDS				RESPONSE TIME	CUE
	START OF MALFUNCTION	THRUST TERM. ABORT LIGHT	RATE LIGHT	ESCAPE INITIATION		
48	69	72.05	72.70	73.06	.36	5.5 deg/sec
48	69	72.05	72.70	73.37	.67	Rate Light
48	69	72.05	72.70	73.19	.49	FDI Low Setting
48	69	72.05	72.70	73.17	.47	
48	69	72.05	72.70	73.14	.44	
48	69	72.05	72.70	73.21	.51	
48	69	72.05	72.95	73.37	.42	8.0 deg/sec
48	69	72.05	72.95	73.30	.35	Rate Light
48	69	72.05	72.95	73.30	.35	FDI Low Setting
48	69	72.05	72.95	73.30	.35	
48	69	72.05	72.95	73.28	.33	
48	69	72.05	72.95	73.27	.32	
48	69	72.05	72.95	73.18	.23	8.0 deg/sec
48	69	72.05	72.95	73.25	.30	Rate Light
48	69	72.05	72.95	73.19	.24	FDI High Setting
48	69	72.05	72.95	73.38	.43	
48	69	72.05	72.95	73.30	.35	8.0 deg/sec
48	69	72.05	72.95	73.19	.24	No Rate Light
48	69	72.05	72.95	73.19	.24	FDI High Setting
48	69	72.05	72.95	73.32	.37	

TABLE V (CONTINUED)

MODE B SRM CASE BURNTHROUGH (OPPOSED) FAILURE DATA
WITHOUT LAUNCH VEHICLE ROLL CONTROL

CASE NO.	TIMES AFTER SRM IGNITION, SECONDS: START OF MALFUNCTION	THRUST TERM. ABORT LIGHT	RATE LIGHT	ESCAPE INITIATION	RESPONSE TIME	CUE
75	51	54.05	54.80	55.22	.42	5.5 deg/sec
75	51	54.05	54.80	55.29	.49	Rate Light
75	51	54.05	54.80	55.22	.42	FDI Low Setting
75	51	54.05	54.80	55.25	.45	
75	51	54.05	54.80	55.40	.60	
75	51	54.05	54.80	55.23	.43	
75	51	54.05	55.05	55.32	.27	8.0 deg/sec
75	51	54.05	55.05	55.39	.34	Rate Light
75	51	54.05	55.05	55.36	.31	FDI Low Setting
75	51	54.05	55.05	55.35	.30	
75	51	54.05	55.05	55.37	.32	
75	51	54.05	55.05	55.35	.30	
76	55	58.05	58.75	59.22	.47	5.5 deg/sec
76	55	58.05	58.75	59.23	.48	Rate Light
76	55	58.05	58.75	59.16	.41	FDI Low Setting
76	55	58.05	58.75	59.20	.45	
76	55	58.05	58.75	59.21	.46	
76	55	58.05	58.75	59.30	.55	
76	55	58.05	59.00	59.30	.30	8.0 deg/sec
76	55	58.05	59.00	59.31	.31	Rate Light
76	55	58.05	59.00	59.30	.30	FDI Low Setting
76	55	58.05	59.00	59.39	.39	
76	55	58.05	59.00	59.32	.32	
76	55	58.05	59.00	59.30	.30	

TABLE VI

MODE B SRM CASE BURNTHROUGH (AUGMENT) FAILURE DATA

	TIMES AFTER SRM IGNITION, SECONDS					
CASE NO.	START OF MALFUNCTION	THRUST TERM. ABORT LIGHT	RATE LIGHT	ESCAPE INITIATION	RESPONSE TIME	CUE
49	24	27.05	27.50	28.06	.56	5.5 deg/sec
49	24	27.05	27.50	28.12	.62	Rate Light
49	24	27.05	27.50	27.96	.46	FDI Low Setting
49	24	27.05	27.50	28.22	.72	
49	24	27.05	27.50	28.09	.59	
49	24	27.05	27.50	28.30	.80	
49	24	27.05	27.75	28.11	.36	8.0 deg/sec
49	24	27.05	27.75	28.49	.74	Rate Light
49	24	27.05	27.75	28.11	.36	FDI Low Setting
49	24	27.05	27.75	28.05	.30	
49	24	27.05	27.75	28.25	.50	
49	24	27.05	27.75	28.38	.63	
49	24	27.05	27.75	27.96	.21	8.0 deg/sec
49	24	27.05	27.75	28.18	.43	Rate Light
49	24	27.05	27.75	28.16	.41	FDI High Setting
49	24	27.05	27.75	28.12	.37	
49	24	27.05	27.75	28.10	.35	8.0 deg/sec
49	24	27.05	27.75	28.14	.39	No Rate Light
49	24	27.05	27.75	28.11	.36	FDI High Setting
49	24	27.05	27.75	28.11	.36	
50	28	31.05	31.50	31.94	.44	5.5 deg/sec
50	28	31.05	31.50	32.28	.78	Rate Light
50	28	31.05	31.50	32.20	.70	FDI Low Setting
50	28	31.05	31.50	32.10	.60	
50	28	31.05	31.50	32.02	.52	
50	28	31.05	31.50	32.05	.55	
50	28	31.05	31.75	32.09	.34	8.0 deg/sec
50	28	31.05	31.75	32.13	.38	Rate Light
50	28	31.05	31.75	32.19	.44	FDI Low Setting
50	28	31.05	31.75	32.15	.40	
50	28	31.05	31.75	32.06	.31	
50	28	31.05	31.75	32.10	.35	

TABLE VI (CONTINUED)

MODE B SRM CASE BURNTHROUGH (AUGMENT) FAILURE DATA

CASE NO.	TIMES AFTER SRM IGNITION, SECONDS: START OF MALFUNCTION	THRUST TERM. ABORT LIGHT	RATE LIGHT	ESCAPE INITIATION	RESPONSE TIME	CUE
51	33	36.05	36.45	36.86	.41	5.5 deg/sec
51	33	36.05	36.45	36.93	.48	Rate Light
51	33	36.05	36.45	36.83	.38	FDI Low Setting
51	33	36.05	36.45	37.03	.58	
51	33	36.05	36.45	37.01	.56	
51	33	36.05	36.45	37.00	.55	
51	33	36.05	36.70	36.99	.29	8.0 deg/sec
51	33	36.05	36.70	37.20	.50	Rate Light
51	33	36.05	36.70	37.05	.35	FDI Low Setting
51	33	36.05	36.70	37.08	.38	
51	33	36.05	36.70	37.11	.41	
51	33	36.05	36.70	37.02	.32	
52	37	40.05	40.45	40.85	.40	5.5 deg/sec
52	37	40.05	40.45	41.12	.67	Rate Light
52	37	40.05	40.45	40.82	.37	FDI Low Setting
52	37	40.03	40.43	41.05	.62	
52	37	40.05	40.45	40.94	.49	
52	37	40.05	40.45	40.94	.49	
52	37	40.05	40.70	41.02	.32	8.0 deg/sec
52	37	40.05	40.70	41.06	.36	Rate Light
52	37	40.05	40.70	41.20	.50	FDI Low Setting
52	37	40.05	40.70	41.03	.33	
52	37	40.05	40.70	41.02	.32	
52	37	40.05	40.70	41.05	.35	
52	37	40.05	40.70	40.97	.27	8.0 deg/sec
52	37	40.05	40.70	41.07	.37	Rate Light
52	37	40.05	40.70	41.02	.32	FDI High Setting
52	37	40.05	40.70	41.07	.37	
52	37	40.05	40.70	41.01	.31	8.0 deg/sec
52	37	40.05	40.70	41.10	.40	No Rate Light
52	37	40.05	40.70	41.00	.30	FDI High Setting
52	37	40.05	40.70	41.07	.37	

TABLE VI (CONTINUED)

MODE B SRM CASE BURNTHROUGH (AUGMENT) FAILURE DATA

CASE NO.	TIMES AFTER SRM IGNITION, SECONDS				RESPONSE TIME	CUE
	START OF MALFUNCTION	THRUST TERM. ABORT LIGHT	RATE LIGHT	ESCAPE INITIATION		
53	48	51.05	51.40	51.90	.50	5.5 deg/sec
53	48	51.05	51.45	51.93	.48	Rate Light
53	48	51.05	51.40	51.76	.36	FDI Low Setting
53	48	51.05	51.40	52.03	.63	
53	48	51.03	51.38	51.89	.51	
53	48	51.05	51.40	51.96	.56	
53	48	51.05	51.60	51.90	.30	8.0 deg/sec
53	48	51.03	51.58	52.00	.42	Rate Light
53	48	51.05	51.60	51.93	.33	FDI Low Setting
53	48	51.05	51.60	51.98	.38	
53	48	51.05	51.60	51.94	.34	
53	48	51.05	51.60	51.98	.38	
54	51	54.05	54.40	54.87	.47	5.5 deg/sec
54	51	54.05	54.40	54.81	.41	Rate Light
54	51	54.03	54.38	54.88	.50	FDI Low Setting
54	51	54.05	54.40	54.89	.49	
54	51	54.05	54.40	54.86	.46	
54	51	54.05	54.40	54.97	.57	
54	51	54.05	54.60	55.21	.61	8.0 deg/sec
54	51	54.05	54.60	55.01	.41	Rate Light
54	51	54.05	54.60	54.92	.32	FDI Low Setting
54	51	54.05	54.60	55.02	.42	
54	51	54.05	54.60	55.00	.40	
54	51	54.05	54.60	54.91	.31	
54	51	54.05	54.60	54.95	.35	8.0 deg/sec
54	51	54.05	54.60	54.81	.21	Rate Light
54	51	54.05	54.60	55.00	.40	FDI High Setting
54	51	54.05	54.60	54.97	.37	
54	51	54.05	54.60	54.81	.21	8.0 deg/sec
54	51	54.05	54.60	54.91	.31	No Rate Light
54	51	54.05	54.60	54.98	.38	FDI High Setting
54	51	54.05	54.60	55.01	.41	

TABLE VI (CONTINUED)

MODE B SRM CASE BURNTHROUGH (AUGMENT) FAILURE DATA

CASE NO.	TIMES AFTER SRM IGNITION, SECONDS				RESPONSE TIME	CUE
	START OF MALFUNCTION	THRUST TERM. ABORT LIGHT	RATE LIGHT	ESCAPE INITIATION		
55	59	62.05	62.40	62.92	.52	5.5 deg/sec
55	59	62.05	62.40	62.77	.37	Rate Light
55	59	62.05	62.40	62.83	.43	FDI Low Setting
55	59	62.05	62.40	62.96	.56	
55	59	62.05	62.40	62.89	.49	
55	59	62.05	62.40	62.78	.38	
55	59	62.05	62.55	63.03	.48	8.0 deg/sec
55	59	62.05	62.55	63.06	.51	Rate Light
55	59	62.05	62.55	62.91	.36	FDI Low Setting
55	59	62.05	62.55	63.01	.46	
55	59	62.05	62.55	62.99	.44	
55	59	62.05	62.55	62.89	.34	
56	62	65.05	65.40	65.96	.56	5.5 deg/sec
56	62	65.05	65.40	65.83	.43	Rate Light
56	62	65.05	65.40	65.72	.32	FDI Low Setting
56	62	65.05	65.40	65.99	.59	
56	62	65.05	65.40	65.91	.51	
56	62	65.05	65.40	65.88	.48	
56	62	65.05	65.55	65.86	.31	8.0 deg/sec
56	62	65.05	65.55	65.99	.44	Rate Light
56	62	65.05	65.55	65.93	.38	FDI Low Setting
56	62	65.05	65.55	65.95	.40	
56	62	65.05	65.55	65.99	.44	
56	62	65.05	65.55	65.88	.33	
57	66	69.05	69.35	69.88	.53	5.5 deg/sec
57	66	69.05	69.35	70.09	.74	Rate Light
57	66	69.05	69.35	69.72	.37	FDI Low Setting
57	66	69.05	69.35	70.03	.68	
57	66	69.05	69.35	69.95	.60	
57	66	69.05	69.35	69.83	.48	
57	66	69.05	69.55	69.87	.32	8.0 deg/sec
57	66	69.05	69.55	69.94	.39	Rate Light
57	66	69.05	69.55	69.33	.38	FDI Low Setting
57	66	69.05	69.55	70.10	.55	
57	66	69.05	69.55	69.89	.34	
57	66	69.05	69.55	70.08	.53	

TABLE VI (CONTINUED)

MODE B SRM CASE BURNTHROUGH (AUGMENT) FAILURE DATA

CASE NO.	TIMES AFTER SRM IGNITION, SECONDS				RESPONSE TIME	CUE
	START OF MALFUNCTION	THRUST TERM. ABORT LIGHT	RATE LIGHT	ESCAPE INITIATION		
58	69	72.05	72.35	72.84	.49	5.5 deg/sec
58	69	72.05	72.35	73.02	.67	Rate Light
58	69	72.05	72.35	72.92	.57	FDI Low Setting
58	69	72.05	72.70	73.20	.50	
58	69	72.05	72.35	72.88	.53	
58	69	72.05	72.35	72.85	.50	
58	69	72.05	72.55	72.87	.32	8.0 deg/sec
58	69	72.05	72.55	72.96	.41	Rate Light
58	69	72.05	72.55	72.99	.44	FDI Low Setting
58	69	72.05	72.55	73.06	.51	
58	69	72.05	72.55	73.08	.53	
58	69	72.05	72.55	72.96	.41	
58	69	72.05	72.55	72.85	.30	8.0 deg/sec
58	69	72.05	72.55	72.83	.28	Rate Light
58	69	72.05	72.55	72.90	.35	FDI High Setting
58	69	72.05	72.55	72.84	.29	
58	69	72.05	72.55	73.04	.49	8.0 deg/sec
58	69	72.05	72.55	72.86	.31	No Rate Light
58	69	72.05	72.55	72.98	.43	FDI High Setting
58	69	72.05	72.55	72.97	.42	

TABLE VI (CONTINUED)

MODE B SRM CASE BURNTHROUGH (AUGMENT) FAILURE DATA
WITHOUT LAUNCH VEHICLE ROLL CONTROL

CASE NO.	TIMES AFTER SRM IGNITION, SECONDS				RESPONSE TIME	CUE
	START OF MALFUNCTION	THRUST TERM. ABORT LIGHT	RATE LIGHT	ESCAPE INITIATION		
77	48	51.05	51.40	51.87	.47	5.5 deg/sec
77	48	51.05	51.40	51.94	.54	Rate Light
77	48	51.05	51.40	51.75	.35	FDI Low Setting
77	48	51.05	51.40	51.98	.58	
77	48	51.05	51.40	51.86	.46	
77	48	51.05	51.40	51.97	.57	
77	48	51.05	51.55	51.82	.27	8.0 deg/sec
77	48	51.05	51.55	52.24	.69	Rate Light
77	48	51.05	51.55	51.92	.37	FDI Low Setting
77	48	51.05	51.55	52.15	.60	
77	48	51.05	51.55	52.08	.53	
77	48	51.05	51.55	51.88	.33	
78	50	53.05	53.40	53.82	.42	5.5 deg/sec
78	50	53.05	53.40	53.93	.53	Rate Light
78	50	53.05	53.40	53.78	.38	FDI Low Setting
78	50	53.05	53.40	54.14	.74	
78	50	53.05	53.40	53.94	.54	
78	50	53.05	53.40	53.86	.46	
78	50	53.05	53.55	53.88	.33	8.0 deg/sec
78	50	53.05	53.55	53.88	.33	Rate Light
78	50	53.05	53.55	53.97	.42	FDI Low Setting
78	50	53.05	53.55	54.01	.46	
78	50	53.05	53.55	53.97	.42	
78	50	53.05	53.55	53.96	.41	

TABLE VII

MODE B TVC NULL FAILURE DATA

CASE NO.	TIMES AFTER SRM IGNITION, SECONDS				RESPONSE TIME	CUE
	START OF MALFUNCTION	THRUST TERM. ABORT LIGHT	RATE LIGHT	ESCAPE INITIATION		
59	28	28.05	29.70	30.22	.52	5.5 deg/sec
59	28	28.05	29.70	30.02	.32	Rate Light
59	28	28.05	29.70	30.14	.44	FDI Low Setting
59	28	28.05	29.70	29.38	-.32	
59	28	28.05	29.70	30.15	.45	
59	28	28.05	29.70	30.25	.55	
59	28	28.05	30.65	31.18	.53	8.0 deg/sec
59	28	28.05	30.65	31.01	.36	Rate Light
59	28	28.05	30.65	30.99	.34	FDI Low Setting
59	28	28.05	30.65	30.77	.12	
59	28	28.05	30.65	31.10	.45	
59	28	28.05	30.65	31.00	.35	
59	28	28.05	30.65	30.93	.28	8.0 deg/sec
59	28	28.05	30.65	31.21	.56	Rate Light
59	28	28.05	30.65	31.02	.37	FDI High Setting
59	28	28.05	30.65	30.87	.22	
59	28	28.05	30.65	30.82	.17	8.0 deg/sec
59	28	28.05	30.65	30.91	.26	No Rate Light
59	28	28.05	30.65	30.92	.27	FDI High Setting
59	28	28.05	30.65	30.90	.25	
60	33	33.05	34.45	34.85	.40	5.5 deg/sec
60	33	33.05	34.45	34.77	.32	Rate Light
60	33	33.05	34.45	34.87	.42	FDI Low Setting
60	33	33.05	34.45	34.88	.43	
60	33	33.05	34.45	34.91	.46	
60	33	33.05	34.45	34.93	.48	
60	33	33.05	35.15	35.46	.31	8.0 deg/sec
60	33	33.05	35.15	35.48	.33	Rate Light
60	33	33.05	35.15	35.51	.36	FDI Low Setting
60	33	33.05	35.15	35.44	.29	
60	33	33.05	35.15	35.60	.45	
60	33	33.05	35.15	35.48	.33	

TABLE VII (CONTINUED)

MODE B TVC NULL FAILURE DATA

CASE NO.	TIMES AFTER SRM IGNITION, SECONDS				RESPONSE TIME	CUE
	START OF MALFUNCTION	THRUST TERM. ABORT LIGHT	RATE LIGHT	ESCAPE INITIATION		
61	40	40.05	41.30	41.69	.39	5.5 deg/sec
61	40	40.05	41.30	41.67	.37	Rate Light
61	40	40.05	41.30	41.75	.45	FDI Low Setting
61	40	40.05	41.30	41.71	.41	
61	40	40.05	41.30	41.75	.45	
61	40	40.05	41.30	41.67	.37	
61	40	40.05	41.90	42.22	.32	8.0 deg/sec
61	40	40.05	41.90	42.19	.29	Rate Light
61	40	40.05	41.90	42.26	.36	FDI Low Setting
61	40	40.05	41.90	42.21	.31	
61	40	40.05	41.90	41.21	-.69	
61	40	40.05	41.90	42.23	.33	
61	40	40.05	41.90	42.19	.29	8.0 deg/sec
61	40	40.05	41.90	42.20	.30	Rate Light
61	40	40.05	41.90	42.23	.33	FDI High Setting
61	40	40.05	41.90	42.26	.36	
61	40	40.05	41.90	42.15	.25	8.0 deg/sec
61	40	40.05	41.90	42.03	.13	No Rate Light
61	40	40.05	41.90	42.19	.29	FDI High Setting
61	40	40.05	41.90	42.18	.28	
62	43	43.05	44.25	44.67	.42	5.5 deg/sec
62	43	43.05	44.25	44.61	.36	Rate Light
62	43	43.05	44.25	44.73	.48	FDI Low Setting
62	43	43.05	44.25	44.00	-.25	
62	43	43.05	44.25	44.66	.41	
62	43	43.05	44.25	44.66	.41	
62	43	43.05	44.70	45.01	.31	8.0 deg/sec
62	43	43.05	44.70	44.98	.28	Rate Light
62	43	43.05	44.70	45.02	.32	FDI Low Setting
62	43	43.05	44.70	44.49	-.21	
62	43	43.05	44.70	44.99	.29	
62	43	43.05	44.70	45.02	.32	

TABLE VII (CONTINUED)

MODE B TVC NULL FAILURE DATA

CASE NO.	TIMES AFTER SRM IGNITION, SECONDS				RESPONSE TIME	CUE
	START OF MALFUNCTION	THRUST TERM. ABORT LIGHT	RATE LIGHT	ESCAPE INITIATION		
63	54	54.05	55.15	55.51	.36	5.5 deg/sec
63	54	54.05	55.15	55.54	.39	Rate Light
63	54	54.05	55.15	55.38	.23	FDI Low Setting
63	54	54.05	55.15	55.42	.27	
63	54	54.05	55.15	55.67	.52	
63	54	54.05	55.15	55.61	.46	
63	54	54.05	55.60	55.90	.30	8.0 deg/sec
63	54	54.05	55.60	55.91	.31	Rate Light
63	54	54.05	55.60	55.98	.38	FDI Low Setting
63	54	54.05	55.60	55.93	.33	
63	54	54.05	55.60	55.90	.30	
63	54	54.05	55.60	55.92	.32	
63	54	54.05	55.60	55.77	.17	8.0 deg/sec
63	54	54.05	55.60	55.97	.37	Rate Light
63	54	54.05	55.60	55.79	.19	FDI High Setting
63	54	54.05	55.60	55.93	.33	
63	54	54.05	55.60	55.84	.24	8.0 deg/sec
63	54	54.05	55.60	55.92	.32	No Rate Light
63	54	54.05	55.60	55.86	.26	FDI High Setting
63	54	54.05	55.60	55.89	.29	
64	58	58.05	59.15	59.57	.42	5.5 deg/sec
64	58	58.05	59.20	59.71	.51	Rate Light
64	58	58.05	59.15	59.65	.50	FDI Low Setting
64	58	58.05	59.15	59.48	.33	
64	58	58.05	59.15	59.66	.51	
64	58	58.05	59.15	59.60	.45	
64	58	58.05	59.50	59.79	.29	8.0 deg/sec
64	58	58.08	59.53	59.90	.37	Rate Light
64	58	58.05	59.50	59.83	.33	FDI Low Setting
64	58	58.05	59.50	59.80	.30	
64	58	58.05	59.50	59.79	.29	
64	58	58.05	59.50	59.83	.33	

TABLE VII (CONTINUED)

MODE B TVC NULL FAILURE DATA

CASE NO.	TIMES AFTER SRM IGNITION, SECONDS START OF MALFUNCTION	THRUST TERM. ABORT LIGHT	RATE LIGHT	ESCAPE INITIATION	RESPONSE TIME	CUE
65	62	62.05	63.10	63.52	.42	5.5 deg/sec
65	62	62.05	63.10	63.53	.43	Rate Light
65	62	62.05	63.10	63.51	.41	FDI Low Setting
65	62	62.05	63.10	63.40	.30	
65	62	62.05	63.10	63.67	.57	
65	62	62.05	63.10	63.52	.42	
65	62	62.05	63.50	63.77	.27	8.0 deg/sec
65	62	62.05	63.50	63.83	.33	Rate Light
65	62	62.05	63.50	63.81	.31	FDI Low Setting
65	62	62.05	63.50	63.81	.31	
65	62	62.05	63.50	63.81	.31	
65	62	62.05	63.50	63.82	.32	
66	65	65.05	66.05	66.47	.42	5.5 deg/sec
66	65	65.05	66.05	66.39	.34	Rate Light
66	65	65.05	66.05	66.47	.42	FDI Low Setting
66	65	65.05	66.05	66.33	.28	
66	65	65.05	66.05	66.50	.45	
66	65	65.05	66.05	66.49	.44	
66	65	65.05	66.45	66.76	.31	8.0 deg/sec
66	65	65.05	66.45	66.77	.32	Rate Light
66	65	65.05	66.45	66.78	.33	FDI Low Setting
66	65	65.05	66.45	66.94	.49	
66	65	65.05	66.45	66.75	.30	
66	65	65.05	66.45	66.84	.39	
67	69	69.05	70.05	70.57	.52	5.5 deg/sec
67	69	69.05	70.05	70.59	.54	Rate Light
67	69	69.05	70.05	70.52	.47	FDI Low Setting
67	69	69.05	70.05	70.39	.34	
67	69	69.05	70.05	70.53	.48	
67	69	69.05	70.05	70.57	.52	
67	69	69.05	70.40	70.78	.38	8.0 deg/sec
67	69	69.05	70.40	70.72	.32	Rate Light
67	69	69.05	70.40	70.81	.41	FDI Low Setting
67	69	69.05	70.40	70.70	.30	
67	69	69.05	70.40	70.69	.29	
67	69	69.05	70.40	70.73	.33	

TABLE VII (CONTINUED)

MODE B TVC NULL FAILURE DATA

CASE NO.	TIMES AFTER SRM IGNITION, SECONDS: START OF MALFUNCTION	THRUST TERM. ABORT LIGHT	RATE LIGHT	ESCAPE INITIATION	RESPONSE TIME	CUE
68	72	72.05	72.95	73.41	.46	5.5 deg/sec
68	72	72.05	72.95	73.48	.53	Rate Light
68	72	72.05	72.95	73.38	.43	FDI Low Setting
68	72	72.05	72.95	73.54	.59	
68	72	72.05	72.95	73.58	.63	
68	72	72.05	72.95	73.49	.54	
68	72	72.05	73.30	73.63	.33	8.0 deg/sec
68	72	72.05	73.30	73.67	.37	Rate Light
68	72	72.05	73.30	73.34	.44	FDI Low Setting
68	72	72.05	73.30	73.64	.34	
68	72	72.05	73.30	73.70	.40	
68	72	72.05	73.30	73.71	.41	
68	72	72.05	73.30	73.69	.39	8.0 deg/sec
68	72	72.05	73.30	73.67	.37	Rate Light
68	72	72.05	73.30	73.63	.33	FDI High Setting
68	72	72.05	73.30	73.65	.35	
68	72	72.05	73.30	73.69	.39	8.0 deg/sec
68	72	72.05	73.30	73.69	.39	No Rate Light
68	72	72.05	73.30	73.63	.33	FDI High Setting
68	72	72.05	73.30	73.64	.34	

TABLE VII (CONTINUED)

MODE B TVC NULL FAILURE DATA
WITHOUT LAUNCH VEHICLE ROLL CONTROL

CASE NO.	TIMES AFTER SRM IGNITION, SECONDS				RESPONSE TIME	CUE
	START OF MALFUNCTION	THRUST TERM. ABORT LIGHT	RATE LIGHT	ESCAPE INITIATION		
69	27	27.05	28.25	28.78	.53	5.5 deg/sec Rate Light FDI Low Setting
69	27	27.05	28.25	28.80	.55	
69	27	27.05	28.26	28.26	.00	
69	27	27.05	28.25	28.37	.12	
69	27	27.05	28.25	28.89	.64	
69	27	27.05	28.25	28.98	.73	
69	27	27.05	28.75	29.05	.30	8.0 deg/sec Rate Light FDI Low Setting
69	27	27.05	28.75	29.24	.49	
69	27	27.05	28.75	29.06	.31	
69	27	27.05	28.75	29.06	.31	
69	27	27.05	28.75	28.33	-.42	
69	27	27.05	28.75	29.28	.53	
70	30	30.05	31.15	31.61	.46	5.5 deg/sec Rate Light FDI Low Setting
70	30	30.05	31.15	31.56	.41	
70	30	30.05	31.15	31.69	.54	
70	30	30.05	31.15	31.32	.17	
70	30	30.05	31.15	31.57	.42	
70	30	30.05	31.15	31.78	.63	
70	30	30.05	31.60	32.01	.41	8.0 deg/sec Rate Light FDI Low Setting
70	30	30.05	31.60	31.90	.30	
70	30	30.05	31.60	31.92	.32	
70	30	30.05	31.60	31.92	.32	
70	30	30.05	31.60	31.90	.30	
70	30	30.05	31.60	31.95	.35	
71	50	50.05	51.00	51.52	.52	5.5 deg/sec Rate Light FDI Low Setting
71	50	50.05	51.00	51.47	.47	
71	50	50.05	51.00	51.32	.32	
71	50	50.05	51.00	51.39	.39	
71	50	50.05	51.00	51.43	.43	
71	50	50.05	51.00	51.39	.39	
71	50	50.05	51.30	51.58	.28	8.0 deg/sec Rate Light FDI Low Setting
71	50	50.05	51.30	51.63	.33	
71	50	50.05	51.30	51.64	.34	
71	50	50.05	51.30	51.69	.39	
71	50	50.05	51.30	51.68	.38	
71	50	50.05	51.30	51.73	.43	

TABLE VII (CONTINUED)

MODE B TVC NULL FAILURE DATA
WITHOUT LAUNCH VEHICLE ROLL CONTROL

CASE NO.	TIMES AFTER SRM IGNITION, SECONDS				RESPONSE TIME	CUE
	START OF MALFUNCTION	THRUST TERM. ABORT LIGHT	RATE LIGHT	ESCAPE INITIATION		
72	55	55.05	55.95	56.51	.56	5.5 deg/sec
72	55	55.05	55.95	56.43	.48	Rate Light
72	55	55.05	55.95	56.47	.52	FDI Low Setting
72	55	55.05	55.95	56.33	.38	
72	55	55.05	55.95	56.43	.48	
72	55	55.05	55.95	56.38	.43	
72	55	55.05	56.25	56.57	.32	8.0 deg/sec
72	55	55.05	56.25	56.56	.31	Rate Light
72	55	55.05	56.25	56.58	.33	FDI Low Setting
72	55	55.05	56.25	56.64	.39	
72	55	55.05	56.25	56.56	.31	
72	55	55.05	56.25	56.59	.34	
73	70	70.05	70.85	71.30	.45	5.5 deg/sec
73	70	70.05	70.85	71.25	.40	Rate Light
73	70	70.05	70.85	71.43	.58	FDI Low Setting
73	70	70.05	70.85	71.30	.45	
73	70	70.05	70.85	71.23	.38	
73	70	70.05	70.85	71.28	.43	
73	70	70.05	71.20	71.51	.31	8.0 deg/sec
73	70	70.05	71.20	71.51	.31	Rate Light
73	70	70.05	71.20	71.82	.62	FDI Low Setting
73	70	70.05	71.20	71.68	.48	
73	70	70.05	71.20	71.50	.30	
73	70	70.05	71.20	71.55	.35	
74	72	72.05	72.85	73.27	.42	5.5 deg/sec
74	72	72.05	72.85	73.32	.47	Rate Light
74	72	72.05	72.85	73.37	.52	FDI Low Setting
74	72	72.05	72.85	73.29	.44	
74	72	72.05	72.85	73.30	.45	
74	72	72.05	72.85	73.44	.59	
74	72	72.05	73.15	73.46	.31	8.0 deg/sec
74	72	72.05	73.15	73.47	.32	Rate Light
74	72	72.05	73.15	73.64	.49	FDI Low Setting
74	72	72.05	73.15	73.59	.44	
74	72	72.05	73.15	73.45	.30	
74	72	72.05	73.15	73.68	.53	

TABLE VIII

STATIC DATA

D-RING RESPONSE TIME AFTER EJECT LIGHT

RESPONSE TIMES IN SECONDS

.262	.233	.237	.225	.229
.215	.322	.243	.223	.229
.230	.256	.269	.226	.231
.229	.223	.237	.238	.216
.233	.218	.223	.243	.227
.266	.244	.316	.259	.279
.266	.268	.298	.275	.266
.297	.289	.289	.268	.293
.252	.264	.263	.329	.292
.252	.263	.256	.264	.293
.258	.231	.233	.245	.230
.219	.237	.231	.235	.221
.226	.242	.228	.232	.231
.241	.237	.234	.235	.245
.253	.242	.228	.240	.245
.246	.298	.289	.284	.350
.278	.278	.407	.362	.308
.325	.278	.329	.295	.306
.282	.299	.302	.308	.274
.355	.392	.299	.304	.316
.291	.298	.315	.270	.324
.266	.281	.256	.273	.276
.236	.237	.294	.268	.247
.279	.244	.244	.246	.228
.263	.266	.301	.251	.281
.296	.297	.248	.236	.228
.229	.224	.232	.248	.245
.227	.226	.215	.234	.221
.201	.232	.213	.214	.205
.220	.219	.238	.204	.212
.238	.220	.214	.236	.231

TABLE IX

STATIC DATA

ESCAPE INITIATION RESPONSE TIME AFTER RATE LIGHT
(START WITH ABORT HANDLE AT THE SHUTDOWN POSITION)

RESPONSE TIMES IN SECONDS

.426	.327	.316	.309	.320
.301	.293	.292	.286	.351
.320	.328	.319	.326	.314
.316	.329	.328	.335	.413
.340	.329	.313	.421	.334
.353	.383	.322	.337	.261
.249	.226	.279	.304	.278
.269	.255	.270	.261	.263
.276	.265	.273	.272	.260
.332	.265	.289	.301	.278
.272	.270	.272	.334	.319
.297	.299	.286	.282	.310
.309	.295	.332	.306	.335
.330	.328	.309	.330	.304
.318	.301	.309	.326	.329
.296	.315	.310	.292	.295
.283	.326	.299	.292	.303
.294	.345	.369	.286	.311
.321	.281	.288	.346	.330
.290	.294	.291	.349	.301
.327	.320	.341	.298	.283
.294	.273	.274	.347	.265
.268	.259	.265	.295	.247
.289	.275	.268	.282	.288
.281	.279	.328	.275	.285
.271	.303	.290	.303	.303
.290	.282	.276	.287	.278
.277	.268	.263	.278	.279
.288	.284	.305	.271	.283
.270	.285	.280	.281	.276
.295	.293	.295	.302	

TABLE X

STATIC DATA

SHUTDOWN RESPONSE TIME AFTER ABORT LIGHT, AND ESCAPE INITIATION RESPONSE TIME AFTER RATE LIGHT

$t_1 = t_{rate\ lt.} - t_{shutdown}$

$t_2 = t_{shutdown} - t_{abt.\ lt.}$ Times Listed in Seconds

$t_3 = t_{esc.\ init.} - t_{rate\ lt.}$

$t_1 = 1.300$		$t_1 = 0.600$		$t_1 = 0.350$	
t_2	t_3	t_2	t_3	t_2	t_3
.266	.314	.290	.274	.279	.320
.281	.268	.286	.253	.264	.286
.292	.266	.277	.295	.277	.297
.281	.305	.245	.275	.277	.269
.252	.290	.303	.254	.278	.270
.335	.274	.266	.273	.280	.274
.300	.282	.266	.256	.284	.269
.279	.265	.277	.265	.312	.279
.313	.261	.269	.269	.329	.350
.301	.266	.292	.271	.274	.265
.289	.291	.307	.259	.307	.326
.292	.261	.290	.268	.301	.278
.292	.280	.297	.276	.293	.296
.281	.275	.295	.278	.285	.283
.290	.283	.300	.274	.389	.354
.288	.283	.296	.271	.277	.291
.310	.305	.298	.283	.288	.283
.312	.263	.325	.266	.285	.273
.328	.264	.289	.266	.305	.270
.301	.271	.275	.292	.290	.258
.289	.314	.306	.263	.302	.274
.291	.263	.310	.264	.289	.277
.292	.268	.319	.264	.310	.271
.321	.271	.353	.308	.301	.281
.292	.274	.373	.289	.298	.273
.354	.258	.406	.286	.333	.317
.314	.331	.530	.296	.309	.322
.326	.270	.432	.295	.338	.299
.336	.248	.446	.311	.380	.305
.374	.251	.370	.294	.409	.291

TABLE X (CONTINUED)

STATIC DATA

SHUTDOWN RESPONSE TIME AFTER ABORT LIGHT, AND
ESCAPE INITIATION RESPONSE TIME AFTER RATE LIGHT

$t_1 = t_{rate\ lt.} - t_{shutdown}$

$t_2 = t_{shutdown} - t_{abt.\ lt.}$

Times Listed in Seconds

$t_3 = t_{esc.\ init.} - t_{rate\ lt.}$

t_1 = 1.300		t_1 = 0.600		t_1 = 0.350	
t_2	t_3	t_2	t_3	t_2	t_3
.409	.264	.368	.314	.445	.325
.369	.246	.416	.320	.379	.300
.397	.288	.418	.310	.382	.342
.377	.255	.406	.283	.433	.312
.424	.283	.449	.298	.349	.334
.430	.262	.410	.291	.382	.287
.435	.262	.436	.303	.432	.342
.369	.268	.351	.399	.422	.314
.332	.260	.343	.317	.567	.357
.335	.271	.422	.278	.373	.313
.344	.246	.435	.298	.318	.299
.340	.292	.347	.280	.387	.331
.335	.274	.385	.281	.376	.351
.419	.244	.363	.288	.439	.314
.410	.257	.356	.293	.352	.292
.382	.253	.373	.287	.344	.318
.403	.233	.405	.262	.380	.311
.362	.279	.431	.328	.330	.308
.403	.251	.429	.264	.398	.307
.413	.248	.434	.303	.368	.302
.406	.306	.445	.409	.342	.310
.421	.277	.352	.307	.360	.300
.345	.286	.541	.324	.331	.313
.496	.264	.482	.464	.426	.464
.447	.309	.403	.284	.497	.303
.440	.296	.442	.326	.395	.371
.417	.316	.400	.328	.415	.338
.459	.299	.450	.300	.445	.453
.436	.286	.503	.303	.438	.341
.419	.341	.510	.291	.368	.314

TABLE X (CONTINUED)

STATIC DATA

SHUTDOWN RESPONSE TIME AFTER ABORT LIGHT, AND
ESCAPE INITIATION RESPONSE TIME AFTER RATE LIGHT

$t_1 = t_{rate\ lt.} - t_{shutdown}$

$t_2 = t_{shutdown} - t_{abt.\ lt.}$

Times Listed in Seconds

$t_3 = t_{esc.\ init.} - t_{rate\ lt.}$

$t_1 = 1.300$		$t_1 = 0.600$		$t_1 = 0.350$	
t_2	t_3	t_2	t_3	t_2	t_3
.447	.283	.469	.302	.428	.347
.496	.278	.457	.354	.441	.349
.529	.285	.603	.315	.470	.314
.650	.316	.544	.264	.466	.302
.381	.287	.579	.336	.500	.313
.438	.284	.434	.300	.441	.318
.506	.335	.463	.298	.646	.362
.368	.284	.509	.267	.432	.317
.543	.295	.420	.321	.671	.354
.508	.289	.355	.268	.451	.314
.438	.293	.429	.288	.508	.502
.334	.288	.336	.306	.538	.392
.378	.251	.330	.261	.364	.318
.339	.285	.353	.299	.362	.408
.381	.271	.377	.301	.369	.331
.408	.261	.387	.272	.361	.270
.322	.254	.385	.269	.342	.335
.378	.254	.366	.270	.369	.331
.431	.311	.406	.277	.401	.274
.327	.376	.383	.282	.382	.280
.361	.264	.303	.342	.414	.284
.358	.304	.380	.283	.342	.293
.411	.242	.321	.281	.306	.311
.356	.301	.357	.264	.352	.292
.326	.285	.350	.275	.371	.268
.353	.253	.371	.267	.328	.288
.323	.286	.318	.311	.359	.277
.370	.287	.381	.291	.357	.289
.368	.250	.368	.360	.296	.330
.360	.289	.311	.300	.313	.311

TABLE X (CONTINUED)

STATIC DATA

SHUTDOWN RESPONSE TIME AFTER ABORT LIGHT, AND
ESCAPE INITIATION RESPONSE TIME AFTER RATE LIGHT

$t_1 = t_{rate\ lt.} - t_{shutdown}$

$t_2 = t_{shutdown} - t_{abt.\ lt.}$ Times Listed in Seconds

$t_3 = t_{esc.\ init.} - t_{rate\ lt.}$

$t_1 = 1.300$		$t_1 = 0.600$		$t_1 = 0.350$	
t_2	t_3	t_2	t_3	t_2	t_3
.384	.261	.390	.269	.356	.349
.316	.281	.325	.283	.421	.283
.341	.275	.341	.283	.389	.268
.371	.257	.291	.264	.414	.282
.359	.302	.333	.274	.362	.256
.327	.259	.345	.278	.347	.303
.408	.280	.380	.278	.395	.290
.436	.275	.363	.262	.328	.291
.418	.302	.413	.324	.329	.277
.461	.301	.376	.333	.351	.311
.462	.303	.419	.304	.486	.304
.423	.285	.407	.319	.377	.292
.374	.293	.428	.316	.404	.351
.425	.295	.434	.312	.445	.368
.389	.284	.389	.274	.433	.359
.381	.302	.414	.281	.527	.321
.371	.272	.362	.308	.435	.356
.463	.283	.441	.326	.506	.297
.496	.270	.396	.321	.427	.313
.373	.311	.470	.292	.402	.369
.375	.298	.426	.297	.385	.348
.415	.279	.399	.298	.369	.303
.377	.292	.440	.286	.426	.301
.363	.279	.362	.306	.438	.301
.454	.281	.619	.288	.423	.312
.349	.283	.433	.305	.419	.285
.357	.288	.376	.292	.372	.319
.358	.305	.401	.318	.423	.315
.434	.290	.419	.300	.479	.338
.480	.309	.412	.334	.384	.305

TABLE X (CONTINUED)

STATIC DATA

SHUTDOWN RESPONSE TIME AFTER ABORT LIGHT, AND
ESCAPE INITIATION RESPONSE TIME AFTER RATE LIGHT

$t_1 = t_{rate\ lt.} - t_{shutdown}$

$t_2 = t_{shutdown} - t_{abt.\ lt.}$ Times Listed in Seconds

$t_3 = t_{esc.\ init.} - t_{rate\ lt.}$

$t_1 = 1.300$		$t_1 = 0.600$		$t_1 = 0.350$	
t_2	t_3	t_2	t_3	t_2	t_3
.396	.287	.449	.284	.381	.306
.445	.300	.504	.299	.479	.297
.446	.286	.372	.297	.492	.340
.429	.289	.421	.295	.375	.324
.399	.318	.407	.331	.461	.331
.357	.301	.363	.338	.468	.371
.349	.291	.397	.326	.366	.316
.399	.303	.431	.310	.361	.371
.419	.294	.368	.308	.522	.314
.351	.282	.375	.306	.507	.391
.465	.284	.384	.327	.501	.376
.458	.296	.458	.318	.367	.336
.417	.268	.494	.287	.631	.307
.438	.275	.340	.291	.402	.349
.451	.297	.426	.280	.357	.341
.419	.289	.359	.327	.359	.295
.396	.280	.436	.304	.357	.378
.456	.272	.479	.324	.446	.324
.501	.352	.419	.300	.415	.327
.488	.299	.428	.296	.365	.363
.407	.285	.402	.296	.475	.314
.364	.280	.771	.322	.430	.311
.407	.289	.368	.305	.474	.344
				.376	.305
				.386	.319

TABLE XI

STATIC DATA

ESCAPE INITIATION RESPONSE TIME AFTER RATE LIGHT
WITH AND WITHOUT PSA GLOVE
(START WITH ABORT HANDLE AT THE SHUTDOWN POSITION)

RESPONSE TIME, SECONDS

WITH GLOVE		WITHOUT GLOVE	
.321	.339	.299	.333
.328	.311	.297	.305
.338	.309	.342	.288
.306	.312	.327	.289
.311	.349	.295	.291
.338	.327	.301	.331
.330	.323	.289	.283
.299	.317	.386	.298
.304	.321	.312	.317
.293	.321	.336	.312
.344	.321	.307	.324
.390	.324	.358	.314
.301	.337	.338	.321
.338	.358	.283	.348
.325	.312	.311	.285
.324	.305	.346	.268
.317	.299	.279	.327
.317	.297	.320	.330
.341	.306	.320	.271
.315	.304	.351	.311
.362	.333	.373	.336
.317	.326	.352	.320
.319	.327	.371	.358
.300	.318	.356	.337
.306	.327	.325	.350
.320	.309	.339	.323

TABLE XII

STATIC DATA
(MEASURED AT MCDONNELL ASTRONAUTICS CO.)

SHUTDOWN RESPONSE TIME AFTER ABORT LIGHT, AND
ESCAPE INITIATION RESPONSE TIME AFTER RATE LIGHT

$t_1 = t_{rate\ lt.} - t_{shutdown}$

$t_2 = t_{shutdown} - t_{abt.\ lt.}$ Times Listed in Seconds

$t_3 = t_{esc,\ init.} - t_{rate\ lt.}$

t_1	t_2	t_3	t_1	t_2	t_3
-.089	.378	.332	.001	.346	.355
-.020	.360	.446	.287	.347	.347
-.074	.364	.374	.317	.405	.304
.086	.368	.359	.173	.327	.322
-.016	.363	.329	.003	.387	.373
.238	.396	.339	-.091	.381	.363
.344	.378	.333	.095	.359	.357
.078	.422	.324	-.065	.412	.370
-.118	.408	.371	-.278	.427	.458
.025	.429	.314	.070	.430	.373
-.030	.377	.334	-.022	.412	.338
.223	.411	.320	-.119	.409	.390
-.275	.424	.436	.038	.416	.333
.104	.396	.331	-.073	.422	.336
-.219	.509	.501	.274	.448	.346
.105	.395	.349	-.051	.398	.355
-.058	.448	.354	.209	.425	.344
-.133	.423	.410	.290	.432	.339
.031	.423	.383	-.051	.551	.428
-.139	.486	.379	-.069	.459	.380
-.005	.395	.385	.195	.439	.325
-.091	.381	.442	.328	.394	.324
.021	.433	.418	.013	.487	.428
-.029	.376	.380	-.054	.444	.330
.133	.501	.321	-.196	.486	.400
-.147	.601	.573	-.313	.602	.628
-.085	.432	.462	-.094	.484	.332
.165	.469	.328	-.086	.376	.367
-.269	.418	.433	.103	.351	.359
.085	.415	.340	-.069	.416	.313
-.292	.441	.529	.067	.387	.360
.111	.389	.328	-.011	.358	.308
-.005	.395	.335	.255	.379	.307

TABLE XII (CONTINUED)

STATIC DATA
(MEASURED AT MCDONNELL ASTRONAUTICS CO.)

SHUTDOWN RESPONSE TIME AFTER ABORT LIGHT, AND
ESCAPE INITIATION RESPONSE TIME AFTER RATE LIGHT

$t_1 = t_{\text{rate lt.}} - t_{\text{shutdown}}$

$t_2 = t_{\text{shutdown}} - t_{\text{abt. lt.}}$ Times Listed in Seconds

$t_3 = t_{\text{esc. init.}} - t_{\text{rate lt.}}$

t_1	t_2	t_3	t_1	t_2	t_3
-.048	.438	.335	.201	.433	.315
-.235	.525	.409	-.239	.388	.402
.056	.398	.313	.136	.364	.315
-.273	.620	.491	.203	.431	.315
-.114	.404	.366	-.261	.410	.421
.055	.399	.323	.101	.399	.339
-.092	.439	.335	-.002	.392	.327
.193	.441	.306	-.098	.388	.318
-.247	.396	.468	.001	.453	.343
.102	.398	.339	-.045	.392	.381
.009	.381	.326	.213	.421	.337
-.181	.471	.372	-.270	.419	.423
.054	.400	.312	.091	.409	.323
-.062	.409	.332	.005	.385	.316
.216	.418	.310	-.102	.392	.337
-.284	.433	.441	.057	.397	.321
.113	.387	.339	-.037	.384	.335
-.012	.402	.327	.233	.401	.319
-.401	.691	.498	-.461	.610	.611
-.422	.769	.610	-.324	.958	.459
-.378	.668	.484	-.321	.470	.500
-.335	.789	.466	-.342	.842	.465
-.410	.757	.524	-.330	.720	.439
-.358	.992	.500	.075	.315	.285
.328	.306	.309	-.028	.318	.257
-.221	.370	.397	.175	.325	.318
.017	.330	.315	.058	.332	.320
.337	.297	.319	-.047	.337	.379
-.176	.325	.403	.119	.335	.333
.033	.314	.316	.052	.338	.376
-.119	.409	.347	-.206	.355	.376
.058	.396	.299	.149	.351	.316
-.025	.372	.316	.156	.344	.327

TABLE XII (CONTINUED)

STATIC DATA
(MEASURED AT MCDONNELL ASTRONAUTICS CO.)

SHUTDOWN RESPONSE TIME AFTER ABORT LIGHT, AND
ESCAPE INITIATION RESPONSE TIME AFTER RATE LIGHT

$t_1 = t_{rate\ lt.} - t_{shutdown}$

$t_2 = t_{shutdown} - t_{abt.\ lt.}$

$t_3 = t_{esc.\ init.} - t_{rate\ lt.}$

Times Listed in Seconds

t_1	t_2	t_3	t_1	t_2	t_3
.290	.344	.315	-.053	.343	.428
-.180	.329	.379	.119	.335	.316
.197	.303	.319	-.009	.356	.329
.036	.354	.309	.312	.322	.312
-.051	.341	.304	-.253	.402	.467
.119	.325	.285	.147	.353	.306
.018	.329	.417	-.513	.903	.646
-.440	1.074	.598	-.578	.868	.681
-.498	.647	.675	-.400	.854	.546
-.364	.864	.474	-.386	.733	.544
-.349	.739	.500	-.355	.989	.452
-.382	.672	.494	-.444	.593	.541
-.396	.850	.550	-.389	.887	.518
-.444	.791	.642	-.439	.829	.579
-.392	1.026	.511	-.404	.694	.570
-.545	.694	.661	-.362	.816	.464
-.401	.901	.613	-.539	.886	.692
-.379	.769	.543	-.347	.981	.508
-.383	.673	.528	-.490	.639	.574
-.410	.864	.524	-.377	.877	.458
-.333	.680	.506	-.358	.748	.527
-.383	1.017	.482	-.022	.412	.339
.190	.444	.346	-.053	.343	.415
.351	.371	.325	.061	.393	.335
-.005	.352	.355	-.062	.452	.352
.273	.361	.367	-.215	.505	.449
.306	.416	.401	.055	.399	.350
.080	.420	.448	-.083	.430	.415
-.082	.472	.331	.200	.434	.293
-.073	.363	.333	-.272	.421	.447
.006	.341	.365	.074	.316	.368
.306	.328	.320	-.034	.324	.384
-.185	.334	.384	.130	.324	.295

TABLE XII (CONTINUED)

STATIC DATA
(MEASURED AT MCDONNELL ASTRONAUTICS CO.)

SHUTDOWN RESPONSE TIME AFTER ABORT LIGHT, AND
ESCAPE INITIATION RESPONSE TIME AFTER RATE LIGHT

$t_1 = t_{rate\ lt.} - t_{shutdown}$

$t_2 = t_{shutdown} - t_{abt.\ lt.}$

$t_3 = t_{esc.\ init.} - t_{rate\ lt.}$

Times Listed in Seconds

t_1	t_2	t_3	t_1	t_2	t_3
.065	.389	.308	.083	.417	.317
-.001	.348	.321	-.091	.481	.341
-.418	.567	.644	.025	.429	.337
.103	.397	.373	-.062	.409	.392
-.199	.408	.380	.326	.396	.349
-.199	.653	.432	-.134	.423	.435
-.099	.446	.416	.041	.349	.338
.215	.419	.401	-.153	.443	.509
.301	.421	.351	.032	.422	.495
.084	.416	.356	-.131	.478	.446
-.058	.448	.448	.188	.446	.361
-.438	.587	.588	-.308	.762	.425
-.343	.843	.470	-.410	.757	.504
-.348	.738	.519	-.336	.970	.435
-.359	.649	.500	-.325	.779	.505
-.328	.828	.503	-.583	.973	.684
-.364	.998	.535	-.446	.736	.615
-.465	.614	.573	-.531	.985	.672
-.363	.863	.492	-.382	.729	.525
-.359	.859	.533	-.452	.799	.653
-.400	.790	.576	-.346	.980	.464
-.367	.657	.788	-.569	.718	.737
-.411	.865	.512	-.372	.872	.498
-.122	.469	.354	-.092	.382	.322
-.194	.343	.391	.134	.320	.310
.163	.337	.303	.012	.335	.363
.066	.324	.355	.282	.352	.312
-.051	.341	.347	-.188	.337	.438
.095	.359	.327	.035	.355	.301
.283	.351	.301	-.028	.318	.330
.163	.337	.300	.024	.323	.411
.075	.315	.304	.287	.347	.316
-.035	.325	.358	-.166	.315	.391

TABLE XII (CONTINUED)

STATIC DATA
(MEASURED AT MCDONNELL ASTRONAUTICS CO.)

SHUTDOWN RESPONSE TIME AFTER ABORT LIGHT, AND
ESCAPE INITIATION RESPONSE TIME AFTER RATE LIGHT

$t_1 = t_{rate\ lt.} - t_{shutdown}$

$t_2 = t_{shutdown} - t_{abt.\ lt.}$

$t_3 = t_{esc.\ init.} - t_{rate\ lt.}$

Times Listed in Seconds

t_1	t_2	t_3	t_1	t_2	t_3
-.153	.302	.342	.119	.335	.302
.172	.328	.300	.032	.315	.355
.078	.312	.293	.293	.341	.325
-.043	.333	.325	-.181	.330	.374
.133	.367	.319	.002	.345	.354
.055	.335	.324	.294	.340	.313
-.418	.808	.590	-.441	1.075	.514
-.477	.767	.574	-.629	.778	.800
-.164	.618	.486	-.405	.905	.969
-.500	.847	.700	-.412	.802	.578
-.426	1.060	.585	-.435	.675	.504
-.473	.622	.583	-.377	.831	.469
-.571	1.071	.692	-.408	.755	.523
-.038	.328	.442	-.197	.346	.410
.114	.340	.322	.166	.334	.315
.016	.331	.318	.092	.298	.307
.284	.350	.315	-.049	.339	.322
-.174	.323	.371	.132	.322	.307
.153	.347	.312	-.023	.370	.333
.047	.343	.340	-.026	.416	.358
.261	.373	.333	-.141	.431	.392
.305	.417	.337	.004	.450	.376
.083	.417	.381	-.051	.398	.369
-.025	.415	.417	.134	.500	.347
-.129	.419	.382	.282	.440	.295
-.070	.524	.395	.068	.432	.370
-.064	.411	.437	-.033	.423	.335
.209	.425	.322	.111	.389	.333
-.050	.397	.367	-.001	.391	[illegible]
.093	.541	.321	-.192	.482	[illegible]
.137	.317	.317	.183	.317	[illegible]
-.077	.424	.309			